"USING COGNITIVE TASK ANALYSIS TO DEVELOP SCENARIO-BASED TRAINING FOR HOUSE-CLEARING TEAMS"

FINAL REPORT

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EXECUTIVE SUMMARY

Problem

According to a 1997 U.S. Marine Corps threat estimate, 45% of the world's population currently resides in urban environments. It is projected that over the next ten years (1997-2007) this percentage will increase to 60% (U. S. Marine Corps Intelligence Activity, 1997). By United Nations' estimates, each day 150,000 people in developing countries move into cities. At this rate, by the year 2025, nearly 2/3 of the world's population will live in urban areas (Villella, 1998).

Increased urbanization has created a rise in Military Operations in Urban Terrain (MOUT), in which units find themselves operating in cities rather than on traditional, uninhabited battlefields. MOUT presents a uniquely challenging environment to soldiers and leaders. Beyond challenging basic tactical skills, these environments call on personnel to make faster, more advanced decisions based on a multitude of environmental information. They must be able to make accurate situation assessments based on a variety of environmental cues, and coordinate to maintain that awareness across the team. For these reasons, it is important for personnel to develop decision-making skills required for house-clearing operations that can be applied to different environments. Building training to develop these skills hinges on an understanding of the decision-making challenges personnel face in urban environments.

Objectives

The aim of this research was to understand perceptual cues used to diagnose events and coordinate actions during house-clearing missions. This was done to support the design of more cognitively-authentic scenarios for future training systems such as the Group Immersive Simulator and Integrated Performance Modeling Environment. To do this, we completed the following objectives:

1. Employ Cognitive Task Analysis (CTA) to identify the critical cues house-clearing teams use to assess their environment and establish shared situation awareness.

2. Develop a critical cue inventory cataloguing the cues needed to create realistic, cognitively-challenging training simulations.

3. Provide recommendations for how to integrate critical cues into effective training simulations.

Approach

We applied theories of Naturalistic Decision Making and Cognitive Task Analysis (CTA) methods to better understand the decision-making requirements inherent in house-clearing tasks. We used the findings from our CTA to identify the critical cues and information Canadian Forces rely upon to operate in urban-based missions.

Findings

Our findings revealed that the perceptual cues experts use to diagnose house-clearing events and coordinate actions cluster into four categories: threat assessment, environmental assessment, situational assessment, and team assessment. Experts in house-clearing operations balance the rapid reception and interpretation of these cues without being overwhelmed by them. This is accomplished through using an interesting mix of all three variations of the RPD model and standard operating procedures. The data demonstrate that these cognitive and procedural processes are so entwined that they can be difficult to separate. Yet, experts move seamlessly between intuitive decision making and standard operating procedure several times within a single mission.

Additionally, we found that the expert house-clearing teams move back and forth between states of collaboration and coordination during the course of a house-clearing mission. Particularly interesting is the effortlessness and almost automatic way in which this occurs, and that it's not dictated by the standard operating procedures.

These findings indicate that training in standard operating procedures combined with intuitive decision making is necessary to achieve skilled performance in house-clearing operations.

Conclusions

Through this research effort, we were able to:

- confirm that expertise exists within the house-clearing task
- demonstrate that CTA is effective for capturing the decision requirements of house clearing
- elicit critical decisions, cues, factors, difficulties, rules, strategies, and other relevant knowledge gained from experience in house clearings
- demonstrate how the results of CTA can be translated into training requirements

This research effort showed that recognition-primed decision making is dominant in the house-clearing environment. Because of this, training that focuses solely on assessment of the physical environment will not adequately prepare operators for performance in these missions. It must also include task requirements that lead trainees to develop the decision and assessment skills experts have communicated as mission critical.

Recommendations for Continued Development

- Observation and analysis of live and or recorded house-clearing training exercises
- Research on how situational assessment shifts are communicated amongst team members
- Developing cognitively authentic simulated environments and training scenarios

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I. INTRODUCTION

As this report is being written, coalition forces continue to fight insurgents in Middle Eastern regions. These missions challenge the skills of military personnel and the tactics used to execute them. The risk of these missions is increased exponentially by the fact that they are carried out in built-up urban environments. In historical military operations (such as WWII), fighting in built up areas (FIBUA) was generally conducted in regions that were devoid of non-combatants. As a result the tactics tended to employ significant firepower directed at suspected enemy positions with the objective of killing the enemy with minimal friendly casualties. Collateral damage was not a great concern except where it would impact subsequent operations. In contrast, current military operations are generally conducted in areas inhabited by both combatants and non-combatants. Termed Military Operations in Urban Terrain, or MOUT, these operations require soldiers to fight enemy combatants while protecting not only friendly units, but also the non-combatants on the battlefield. This has resulted in significant modifications to tactics in an attempt to reduce collateral damage. Preparing military personnel to operate successfully in these environments is crucial but nontrivial.

MOUT presents a uniquely challenging environment to soldiers and leaders on many levels. They must discriminate between enemies and civilians, both of whom wear street clothes, when the two are intermingled. The MOUT terrain is peppered with buildings and city streets rather than hills and foliage, requiring alternate mindsets regarding how to leverage terrain. Further, the fact that key aspects of the operational environment (like threat level and presence of religious sites) can change from one area of operations to the next can challenge basic tactical skills. In general, these environments call on personnel to make faster, more advanced decisions based on a multitude of environmental information. Military personnel must be able to make accurate situation assessments based on a variety of environmental cues, recognize when the situation has changed, and coordinate to maintain awareness across the team. For these reasons, it is important for personnel to develop decision-making skills that can be adaptable across MOUT tasks and situations. Building training to develop these skills hinges on an understanding of the decision-making challenges personnel face in urban environments. Our research was motivated by this training need.

Research Goals

The goal of this effort, funded by Defence Research and Development Canada (DRDC)-Toronto, was to identify the perceptual cues Canadian Forces (CF) rely on to facilitate decision making in the urban environment. This was done in an effort to support the development of more robust and effective training scenarios. By incorporating more decision-based scenarios, training simulators such as the Group Immersive Simulator (GIS) can be used as experimental tools to test and evaluate soldiers' performance.

With this primary goal in mind, we focused on the decision-making requirements inherent to house-clearing tasks through three research objectives:

1. Employ Cognitive Task Analysis (CTA) to identify the critical cues house-clearing teams use to assess their environment and establish shared situation awareness.

2. Develop a Critical Cue Inventory based on the CTA cataloguing the perceptual cues needed to create realistic, cognitively-challenging training scenarios.

3. Provide recommendations on how to integrate critical cues into effective training scenarios.

The ultimate goal is to use the output of this research to develop CF training that has a greater impact and results in better transfer of skills than existing procedural training. This will be done by incorporating the cues, information, and decision-making challenges soldiers will encounter in urban missions into training scenarios. This research feeds directly into current advances in training for Canadian Forces.

Advancing Training for Canadian Forces

Future Canadian Forces will provide support for public safety and emergency preparedness incidents, as well as participate in foreign peace support, Operations Other Than War (OOTW), and MOUT missions. These military functions will most likely be conducted in densely populated cities, where enemy combatants, non-combatants, journalists, and humanitarian aid workers can occupy the same built-up area. Extreme caution will need to be taken to avoid casualties and unnecessary loss of innocent lives while trying to fulfill mission objectives, which might include counter-insurgency such as clearing and securing buildings.

Modern house-clearing techniques, like those advocated by current CF where members of the house-clearing team engage entities present with relevant force (not necessarily lethal force), might be best suited for operating in highly populated urbanized settings. Currently, CF's training and rehearsals for FIBUA are conducted in mock-up towns with real building structures that replicate typical urban town areas. In the near future the use of virtual reality technology, specifically through the use of Dismounted Soldier Simulators such as the upcoming Group Immersive Simulator will enable Canadian Forces to conduct effective virtual training and rehearsals in modern military operations.

The physical fidelity (i.e., the faithful duplication of all aspects of the environment, such as bricks on buildings) of simulators and training sites is important to a certain degree in order to emulate mission environments. However, *cognitive* fidelity is more critical in order to produce the desired learning outcomes. A training setting with high cognitive fidelity is one where the information, uncertainties, goal conflicts, and decision dilemmas presented to the student are realistic and based on actual situations that he or she is likely to encounter. Therefore, the development of a registry or repertoire of meaningful cognitive cues and other environmental features that can drive scenario generation will allow for more effective training, rehearsals, and experiments. Adding these elements to scenarios will create more robust training that will allow CFs to develop the relevant decision-making skills for house-clearing tasks. The output of this research will support training developers in creating simulations that target key decision-making and team performance skills for Canadian Forces.

Report Overview

In the remainder of this report, we discuss the theoretical foundation of this research, and document our tasks for achieving the aforementioned research goals. First, we discuss the Recognition-Primed Decision Making and Cognitive Tasks Analysis concepts on which this research was based. Second, we describe the Cognitive Task Analysis-based knowledge elicitation and analysis conducted for the purpose of identifying the critical cues and information requirements needed to successfully execute house-clearing tasks. Finally, we present implications of this Cognitive Task Analysis research to training development and provide recommendations for how to incorporate critical cues to enhance simulation-based training.

II. EXPERTISE AND RECOGNITION-PRIMED DECISION MAKING

Training developers have a goal of leveraging emergent virtual technologies to develop scenarios to prepare CFs for house-clearing missions. Our goal in this effort was to advance that initiative by identifying critical cues house-clearing teams use to assess their environment and take appropriate action. The resultant scenarios will include the key cognitive and decision-making challenges faced by CFs in house-clearing missions, making the training authentic and thus, more effective.

The key to designing training for complex tasks like house-clearing is *cognitive authenticity* (Ross, Halterman, Pierce, & Ross, 1998; Ross & Pierce, 2000). Cognitive authenticity refers to the emulation of features that an expert would perceive in a specific domain to support decision-making. For example, assessing a situation to determine an entry point is a key decision military leaders must make when entering a building during MOUT (Phillips, McCloskey, McDermott, Wiggins, Battaglia, Thordsen, & Klein, 2001). Cognitive authenticity is based on real, lived experiences. This is in contrast to physical fidelity, which is more strongly represented in current training. Physical fidelity includes the precision of visual cues, such as leaves on trees. Although physical fidelity is important for some aspects of training (such as the assessment of visual cues in the environment), alone it is not sufficient for training the multitude of skills needed to perform house-clearing missions. Through isolating and describing the decision-making processes used during house-clearing missions, we will increase the cognitive authenticity in CF training and incorporate high physical fidelity only in service of cognitive authenticity.

The concept of cognitive authenticity and the methods for developing cognitively authentic training are drawn from the field of Naturalistic Decision Making (NDM) (Klein, 1993; Klein, 1989) and are achieved through the application of Cognitive Task Analysis (CTA).

Overview of Expertise

Given the expectation that an increasing number of military personnel will participate in MOUT, it is necessary to capture MOUT-specific knowledge from experts and make it available to less experienced operators through decision-centered training. Expert knowledge is largely

tacit in nature and can be difficult to uncover and describe. Experts have an intuitive grasp of their situations. Their performance is fluid, flexible, and highly proficient.

Expert performance is based on extensive knowledge that is "indexed." Indexing consists of facts and causal relationships being linked in terms of:

- **Cues**: If I see this, it means this larger pattern probably exists in the situation.
- **Expectancies**: In that pattern, I've usually seen things unfold in this way.
- **Goals**: It's important in this type of situation to do this.
- **Typical actions**: I've seen this goal achieved by doing the following.

The resulting patterns of cues, expectancies, goals, and typical actions are encoded in mental models. Mental models include both contextualized technical knowledge and cause-and-effect relationships which vary from domain to domain. This indexed knowledge is what enables expert levels of performance, or recognitional and intuitive decision making.

Developing an expert's knowledge base is not just a simple process of memorizing large amounts of de-contextualized factual information and principles, or of being exposed to a variety of circumstances. Simply knowing a lot of information or rules about situations will not meet the two conditions for developing expertise. First, the individual must acquire information in a manner that makes it mentally accessible in the appropriate situations, (i.e., the information must be indexed as it occurs in real situations). When information is appropriately indexed, a cue is recognized immediately, and it calls forth the associated information appropriate for conditions of similar situations. The same piece of information may or may not be a cue in situations with different conditions. Indexing of information during experiences allows the expert to quickly see through large amounts of information and spot cues in new situations. Second, the individual must practice recognizing cues, expectancies, goals, and actions and performing mental simulation in context. Knowing what is typical in a domain and using that information to act in a situation are two different types of knowledge. Expert mental models are not verbally encoded, but are based on largely unconscious recognition. Therefore, one must *practice* making decisions and planning in a context that provides the elements to which experts attend.

Researchers currently studying CF teams believe team members enter a built-up environment, detect meaningful cues, and hone in on relevant aspects of the events. This, in turn, enables them to recognize patterns, based on previous experience, and initiate an appropriate action, which is usually not optimal, but is good enough to deal with the demands of the situation. This process ties directly to our research in decision making, which has shown that experts do not follow a traditional decision-making approach of rational choice. Rather, they rely on their intuition—skills built up through repeated experiences that they have linked together to form patterns (Klein, 2004). This ability is especially crucial in situations such as house clearing that do not allow time for the development and evaluation of multiple courses of action. The outcome of this research is captured in the Recognition-Primed Decision (RPD) Model. This model provided a theoretical foundation for this research effort.

Recognition-Primed Decision Making

When we speak of expertise we refer to individuals who have achieved exceptional skill in one particular domain. Glaser (1996) describes the following characteristics of expertise as it develops:

- Variable, awkward performance becomes consistent, accurate, complete, and efficient;
- Individual acts and judgments are integrated into overall strategies;
- With perceptual learning, a focus on isolated variables shifts to perception of complex patterns; and
- There is increased self-reliance and ability to form new strategies as needed.

The RPD Model (Figure 1) fuses two processes involving expertise: the way decision makers size up the situation to recognize which course of action makes sense, and the way they evaluate that course of action by imagining how it will play out.

The first process in the RPD model is about recognition. It consists of four aspects—cue recognition, generation of expectancies, identification of relevant goals, and recognition of typical actions. Recognition is based on matching mental models that have been created through previous experience with features of the current situation. Recognition is seldom based on one-for-one matching of an entire situation to a previously experienced situation. If this were true, expertise could be developed by learning a "playbook" for a definitive set of situations encountered in practice. Instead of using a one-for-one pattern matching process, the expert recognizes features, or cues, in a situation from a number of previous experiences.

The second process in the RPD Model is about mental simulation to support a decision for a course of action. After the expert has assessed the situation to a satisfactory degree, he or she recognizes an action that can be taken to meet the goals of the situation. Notice that an expert generates a *single* course of action. To ensure that the action is satisfactory, he or she uses the process of mental simulation to evaluate how well it fits the current situation. The course of action need not be perfect, but it must be satisfactory in terms of risks and uncertainty. Experts almost always decide to go with the first course of action they recognize.

The RPD model has three variations which illustrate how the processes described above are used to make decisions when situations are typical and when they are unfamiliar. When decision makers recognize a situation as typical and familiar, they understand what types of goals make sense (so the priorities are set), which cues are important (so there isn't an overload of information), what to expect next (so they can prepare themselves and notice surprises), and the typical ways of responding in a give situation. By recognizing a situation as typical, they also recognize a course of action likely to succeed. The recognition of goals, cues, expectancies, and actions is part of what it means to recognize a situation. This is the basic strategy which we refer to as Variation 1 of the RPD model.

Some situations are more complex and a variation in the RPD model occurs. In these situations, the decision maker may have to devote more time to diagnosing the situation, since the information may not clearly match a typical case or may map onto more than one typical case. The decision maker may need to gather more information in order to make a diagnosis. Another complication is that the decision maker may have misinterpreted the situation but does not realize it until some expectancy has been violated. At these times, the decision makers will respond to the anomaly or ambiguity by checking which interpretation best matches the features of the situation. This is Variation 2 of the RPD model.

Variation 3 of the RPD model explains how decision makers evaluate single options by imagining how the course of action will play out. A decision maker who anticipates difficulties may need to adjust the course of action, or may reject it and look for another option. Figure 1 illustrates the three forms that RPD can take.

Before the RPD Model was developed, traditional decision researchers were aware that under certain conditions people could not use a rational choice strategy. The significance of the RPD Model is that it describes the most frequently used decision strategies and it explains how people can use experience to make difficult decisions.

Understanding these recognitional processes is also integral to *training* complex cognitive tasks. Without recognition of salient situational cues, expectancies, typical goals, and typically successful actions, the trainee has no anchors to help him understand a situation and quickly generate a basic idea of what will work. Inexperienced individuals often spend too much time generating courses of action and comparing them against each other instead of mentally simulating and deepening on a basically satisfactory course of action vis-à-vis features of the situation. Good recognitional abilities leave time to study the situation deliberately, if needed, once an action has been decided on in order to fine tune execution.

As stated earlier, the information experts use to support these decision-making processes is tacit and often hard to uncover. Our goal was to unpack this tacit knowledge in order to augment training content. The most viable methods for understanding expertise and translating expert experiences into simulated training are those that are part of the Cognitive Task Analysis methodologies. This family of methods was leveraged for this effort to identify decision and training requirements.

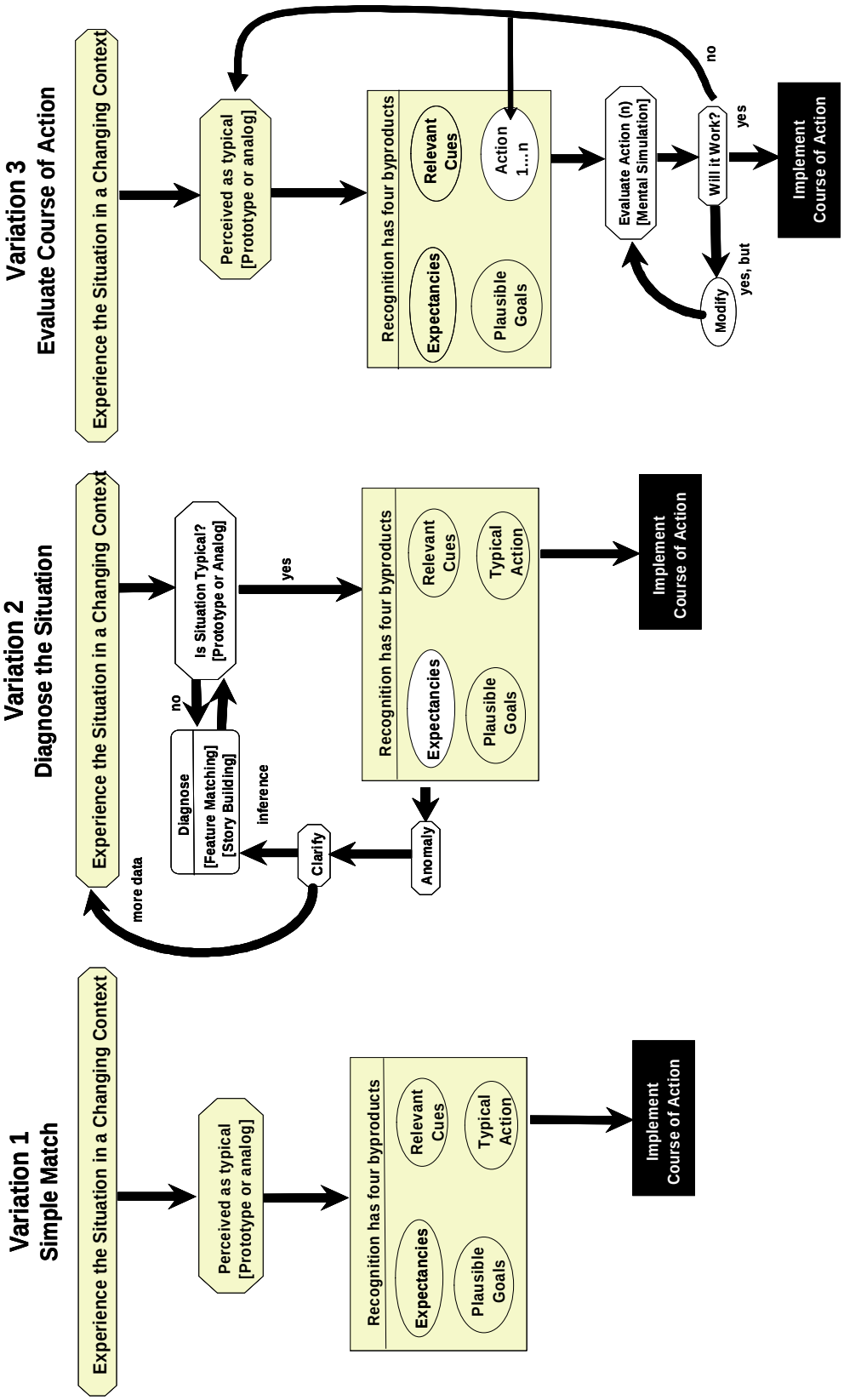


Figure 1. Recognition-Primed Decision Model.

Cognitive Task Analysis

Cognitive Task Analysis (CTA) is the first step for understanding the processes, cognitive demands, and training requirements for a particular domain or set of tasks. CTA is a family of methods and tools that capture the cognitive aspects of performing tasks rather than the observable procedures. CTA allows us to go beyond procedural textbook knowledge and the behavioral aspects of a task that are traditionally elicited and represented by a behavioral task analysis. Through these methods, researchers are able to extract subtle perceptual cues and assessments of rapidly-changing events that experts are not typically able to articulate. The content of the data these methods yield is richer in variety, specificity, and quantity than is typically available in experts' verbal reports (Crandall, Klein, & Hoffman, in preparation).

Among other things, CTA can provide a framework for training developers to treat tacit knowledge explicitly and incorporate that knowledge into a final product. Cognitive Task Analysis allows us to document the cognitive processes behind the behaviors and judgments related to particular tasks. By documenting such cognitive processes, we can apply an understanding of how the user actually thinks, what task elements are challenging, and what support is needed, in order to develop effective training applications.

Cognitive Task Analysis typically consists of distinct phases of knowledge elicitation, analysis, and knowledge representation:

Knowledge Elicitation

Knowledge elicitation is the process of extracting information, through in-depth interviews and observations, about cognitive events. Ensuring the quality of the CTA knowledge elicitation and the validity of the training is dependent upon interviewing subject-matter experts (SMEs) with real-world experience that extends beyond textbook knowledge of house clearing. Many of the CTA knowledge elicitation methods (such as the Critical Decision Method) involve the recounting of specific incidents. Although recall of specific events cannot be assumed to be perfectly reliable, these methods have been highly successful in eliciting perceptual cues, details of judgment, and decision strategies that are generally not captured with traditional reporting methods (Crandall, 1989). Moreover, critical incident methods provide information from the perspective of the person performing a task, and can be particularly useful in identifying cognitive elements that are central to its proficient performance.

Analysis

Cognitive Task Analysis processes allow data to be structured by selecting, simplifying, and transforming information to develop explanations and extract meaning. One of the advantages of CTA is that it lends itself to a variety of qualitative and quantitative approaches to data analysis. Because the field of CTA is still relatively new, there are not well-established validity criteria, or standard analytic practices for handling data (Cooke, 1994). There are, however, excellent models of data analysis which address issues involved in verbal protocol analysis (Ericsson & Simon, 1993; Patrick, 1992) and qualitative data analysis (Miles & Humberman, 1994). Given the more than 100 CTA studies we have conducted to date, we

have considerable experience in data structuring and have developed a number of CTA data analysis strategies (Militello, Hutton, Pliske, Knight, & Klein, 1997).

Because CTA can be used to generate an inventory of cues that can be defined as training requirements, we counted on the selected methods to allow us to generate a Critical Cue Inventory to compile the cues relied on by house-clearing teams to make situational assessments.

Knowledge Representation

Knowledge representation is the process of displaying the relationships and meaning derived from data analysis. There are several methods used to generalize research findings, including decision requirement tables, concept maps, critical cue inventories, and other visual depictions. Knowledge representation is important for enabling others—such as technology and training developers—to understand and apply the results of the CTA.

Described in the following sections of this report is our application of CTA to address the goals of this effort. Specifically, we discuss our knowledge elicitation, analysis, and representation processes.

III. DATA COLLECTION: PLANNING AND EXECUTION

To enhance CF training for urban missions by identifying the domain-specific critical cues and information requirements, we applied theories of Naturalistic Decision Making and CTA methodologies. As stated in the previous CTA section, it is important that interviews be conducted with SMEs who possess real-world experience. While this work is feeding into training for CFs, we were unable to access CF SMEs due to deployment and training schedules. Thus, it was important for us to find an appropriate domain that provided comparable operational experience. These SMEs had to utilize comparable tactics and, more importantly, engage in many of the same critical decisions as CFs. Royal Canadian Mounted Police Emergency Response Teams (RCMP ERTs) were identified as the most appropriate analog.

Canadian Force tactics are becoming more similar to those used by police ERTs in their operations. The situations in which ERTs operate are similar to those encountered by the military in some of their current operations. For the ERT, collateral damage is to be avoided, but this can be complicated by the difficultly of distinguishing between combatants and non-combatants. To make this discrimination, ERT members must be able to scan their environment to recognize potential threats and respond swiftly and appropriately. As a result, ERTs follow a much more restrictive open fire policy than traditional military operations. In an effort to minimize the risk to police personnel, they tend to secure all the occupants of a building and then sort out enemies and friendlies after the operation.

Canadian Forces are beginning to follow similar tactics. They are trained to enter a room, scan for threats and secure the occupants. They use similar tactics including effective scanning procedures, threat identification and response, as well as drills to respond to hostile threats. Canadian Forces are moving toward a more restraining open-fire policy to achieve less collateral

damage. With this clear overlap in decision challenges, ERTs proved to be the best domain to explore for this effort.

In preparing for data collection with ERTs, we considered the intent of the Dismounted Soldier Simulators to provide training for general (not situation or team specific) house-clearing missions. To achieve this desired generalizability, we chose to employ CTA methods that target individual rather than team decision-making. This would allow us to get a range of cues and information requirements across a number of different missions, rather than one or two specific incidents. This will maximize the ability to use the simulators to train a range of perceptual cues relevant to a variety of house-clearing missions.

The following sections describe our data collection goals, methods, and interviews with RCMP ERTs.

Objectives and Preparation

Data collection was aimed at identifying the critical cues house-clearing teams use to assess the operational environment. With that end in mind, four objectives were specified:

1. Describe the challenging tasks inherent to house-clearing missions
2. Identify critical cues and information used by individuals and teams to develop and maintain situation awareness (SA) during house-clearing missions
3. Understand how information is shared between team members to support shared situation assessment and awareness
4. Explore expert-novice differences in performance.

To prepare for data collection, we outlined the goals and critical information to be gleaned from the interviews. Our process for developing the data collection guide follows.

Data Collection Guide Development

The data collection materials were guided by two frameworks. The first was *Macrocognition*. Macrocognition is a term describing those cognitive processes that characterize how people think in natural, field settings. It focuses on those functions not usually explored in a laboratory setting—such as decision making, problem solving, and situation assessment. Macrocognition is in contrast to microcognition, which describes processes that have been examined in laboratories, such as whether attention is parallel or serial or how people solve puzzles (Crandall, Klein, & Hoffman, in press). Because microcognitive processes are studied in controlled settings, they do not adequately capture the complexity of naturalistic tasks.

Twelve macrocognitive functions and processes commonly observed in decision-making research are shown in Figure 2. This diagram illustrates the cognitive processes necessary at individual and team levels. Data collection for this effort was designed to explore house-clearing teams' execution of these key functions and processes. To effectively enter and perform in built-

up areas, teams have to coordinate, plan, and adapt to the situation. To make effective decisions, they must identify key leverage points, manage their attention to environmental changes, and maintain common ground. Thus, Macrocognition provided a solid theoretical foundation with which to identify the critical cognitive skills necessary for house-clearing missions.

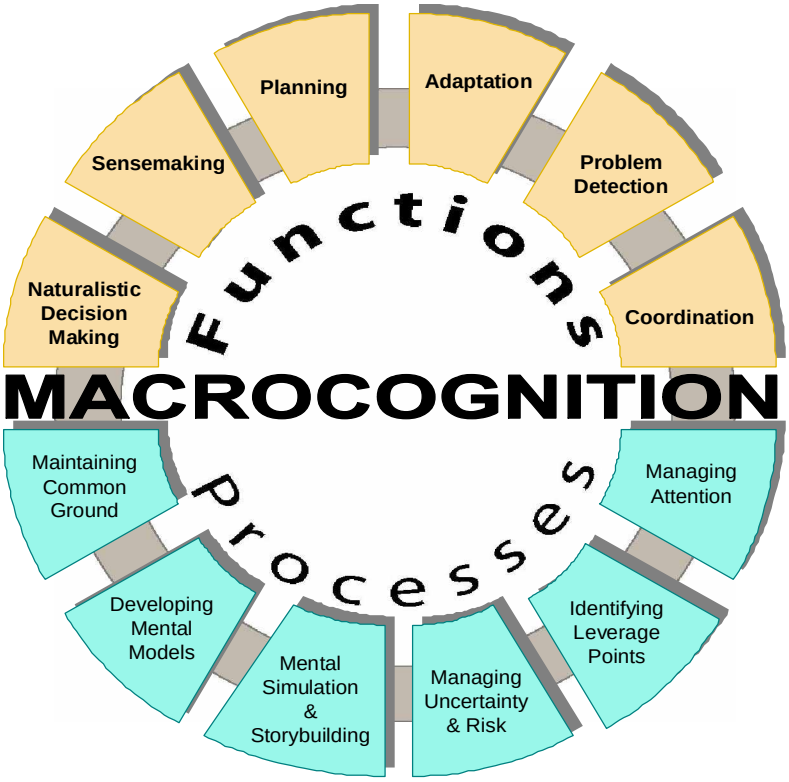


Figure 2. The Macrocognition Diagram.

Five Macrocognitive functions were identified as relevant to this effort: sensemaking, replanning, problem detection, coordination, and situation assessment. Because this effort focused on the execution of the mission (post-planning), planning was not identified as an explicit process to focus on. Common characteristics of Naturalistic Decision Making, such as time pressure and uncertainty, would be probed for throughout interviews and across other functions. To help us think about where these cognitive functions may be relied upon at what points in a house-clearing mission, we referred to a second framework; our past research in MOUT.

Previous research conducted by Klein Associates for the U.S. Army Research Institute (ARI) developed decision-centered training for small-unit leaders in MOUT (Phillips et al., 2001). This project explored different strategies for representing knowledge and creating a usable interface for displaying complex information. Cognitive Task Analyses were conducted with MOUT experts from the 75th Ranger Regiment to determine the decision challenges and critical cognitive components of MOUT building-clearing operations from the perspective of a platoon leader. In this research, Klein Associates identified a set of *task-focused* decision requirements (linear steps involved in a building-clearing operation) and *task-independent* decision requirements (mental tasks that are critical across all stages of a building-clearing

mission and should be active at any point during the operation). Figure 3 shows the relationships between these decision requirements. Those inside the circles are task-focused. The requirements arched above the circles are task-independent, and apply across all of the task-focused decision requirements.

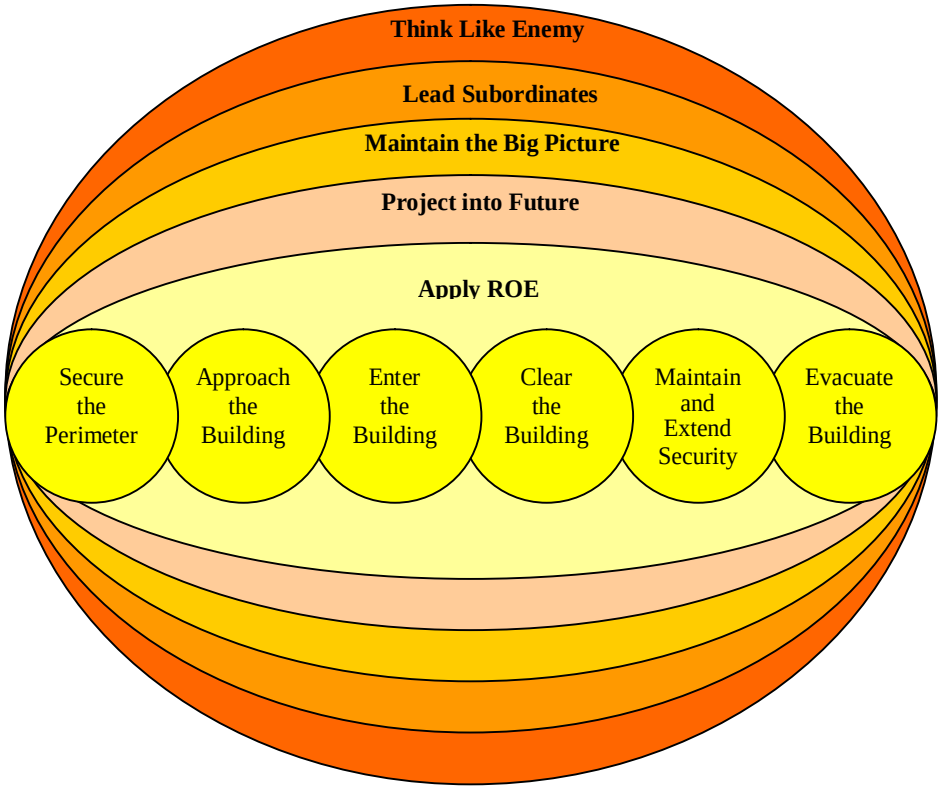


Figure 3. MOUT decision requirements.

Each of the 11 decision requirements is relevant during pre-mission planning as well as during mission execution. A plan only survives until first contact with the enemy, and in nearly every building-clearing operation, it was found that the plan developed prior to the mission broke down to some extent during its execution. Therefore, it is important to understand the decision requirements needed for teams to perform, and to readjust their performance in response to environmental changes. Leveraging this previous MOUT research provided a baseline understanding of the decision-making challenges encountered in the environments in which ERTs perform. It also provided a starting set of cognitive challenges to explore during data collection.

Since this project was focused on how individuals assess situations, and how that information is used (communicated and interpreted) to establish and maintain shared SA among the team, we organized information to determine what Macrocognitive functions were most relevant for 1) the critical house-clearing tasks identified in the MOUT research and 2) for the individual team member and or team as a whole. We defined “relevance” on two levels:

1. Is this Macrocognitive function important for individuals or teams performing this task (e.g., is sensemaking important for individuals when securing the perimeter? Is it important at the team level when securing the perimeter?)
2. Is this Macrocognitive function important to our customer (e.g., is there interest in replanning at the individual or team level?) With regard to this level, there were times when the function was not explicitly asked for by the customer, but was important for understanding this task and thus was marked as important to the customer (e.g., replanning can be an important decision process for teams during the "clear building" task even though replanning has not been explicitly stated as an interest area for research).

Engaging in this process helped us establish a baseline understanding of the task and cognitive challenges involved in house-clearing missions. The output of this step was a three-part matrix identifying which macrocognitive functions are important for which house-clearing tasks (Appendix A). Critical tasks identified through this effort will be discussed in the following sections.

Combining these frameworks into this matrix helped us pinpoint information needs to support training development (based also on training gaps and project goals). Identified information needs included:

- Critical cues (identification and interpretation) for house-clearing missions
- Information seeking (push and pull)
- Sensemaking
- Information sharing
- Common ground (creation, divergence, breakdown)
- Team sensemaking
- Cues regarding team member condition (Cognitive and physical condition. How might this affect how diligent they are in their attention and collaboration?)

Method Selection

To address the four data collection objectives and assemble data around the information needs, three CTA methods were selected for data collection (Militello & Hutton, 1998):

1. **Task Diagram:** The Task Diagram serves as a starting point for the CTA. It provides an overview of the task and the cognitively complex elements of the task. This method was selected to support understanding the cognitively challenging tasks involved in house-clearing missions. By understanding these tasks, we could begin to explore the critical cues and information used in making judgments and decisions around those tasks.
2. **Decision Requirements Exercise (DRX):** The Decision Requirements Exercise makes explicit the critical decisions and judgments individuals and teams must make

to carry out a task. The DRX was selected because it serves as a good follow-on to the Task Diagram. It begins to uncover the critical cues and information relevant to each of the cognitively challenging tasks identified. Understanding these decision requirements will enable us to enhance current training approaches by incorporating the cognitive aspects of proficient task performance.

3. **Scenario-Based Interview:** The scenario-based interview provides a view of the SME's problem solving in a specific context. With this method, SMEs are given a scenario to work through and discuss what decisions they would make in response to the situation. Due to the dynamic nature of the decision environment we were exploring, we selected this method as a way to discuss the decision-making challenges in context.

These specific methods (and their associated probes) were supplemented with questions from Scientists from DRDC. We also included probes from other CTA methods that would not be used formally, but offered value to this research. These included critical incident and team CTA probes.

At the end of this process, we developed a data collection guide. This guide outlined methods, initial probes, and goals for the individual and team interviews. Probes listed on the interview guide served as a starting point for additional exploration throughout the interview. The data collection guide used for this effort can be found in Appendix B.

Data Collection Process

Data were collected over two days with RCMP ERTs during their annual Candidate Selection Course at the Land Force Central Area Training Centre (LFCATC), Meaford, Ontario (March 28-29, 2006). Two Klein Associates researchers conducted individual interviews with members of the RCMP ERT from Toronto and Quebec (n = 7). Subject-matter experts also served as trainers for the 24-hour selection course, so interviews were conducted around their training schedule. Below we outline the process by which each of the CTA techniques was employed during the interviews.

Types of House-Clearing Missions

Before collecting data on the tasks and cues involved in house-clearing missions, we wanted to understand the different types of missions. We started the first three interviews by asking if there are different types of house-clearing missions. The responses from the first three SMEs were consistent; therefore, we did not continue to ask the question of subsequent SMEs.

There are two types of house-clearing missions: dynamic and stealth. Dynamic house clearing (or dynamic entry) involves high energy and quick movement. Teams kick the door in and move swiftly through the space. Stealth house-clearing involves quiet entries with the possibility of becoming dynamic. Typically, approaches are stealth so the target does not know the ERTs are coming. Once the door is breached, the mission becomes dynamic.

In addition to understanding the types of missions, we also wanted to understand the basic mission process, or standard operating procedure, in order to structure the data collection and analysis:

1. **Planning:** The RCMP ERT is called in by an Investigator for a mission (drug bust, hostage situation, remove suspect from residence). Intel is collected by the Investigator and members of the ERT.
2. **Pre-Entry:** ERT members stage at the entry point. This involves each member standing in line, with the Breacher in the lead position. To indicate preparation, each member (starting in the back of the line) taps the shoulder of the person in front. When that tap reaches the Breacher, he gives a "thumbs us" to the team behind him to indicate readiness (non-verbal communication).
3. **Breach:** The Breacher breaks down the door while the rest of the stack stands behind or to the side of him (typically determined in pre-planning).
4. **Entry:** The team enters the building. Sometimes, the first member to enter may be the Breacher. Other times, the Breacher may move quickly to the side to allow the rest of the team to enter. The first member in turns right or left and clears the near corner on that side of the room. The second member in the stack goes the opposite direction of the first member and clears the near corner on that side of the room. Each subsequent member in the stack goes the opposite direction of the member in front of them and clears their area of responsibility.
5. **Clearing:** The team proceeds to clear the house, with each team member covering their own area of responsibility. Once a team member has cleared their area they will, if needed, move to cover a teammate who has indicated a need for backup or go to another area to provide support. At the end of the clearing, the team reports out to the Team Leader and Investigator. The Team Leader checks the residence to ensure all areas were cleared. The Investigator then takes over to arrest any secured suspects.

The data collection and analysis discussed in this and the following sections present information relevant for performance in both types of missions, assuming this basic mission process.

Task Diagram Interviews

The goal of the Task Diagram interview was to identify the cognitively challenging tasks inherent to house-clearing missions. To achieve this, SMEs were asked to consider their role as a member of the ERT, and to decompose their job into four to seven primary tasks. This was done through the use of three structured probes.

- ***Initial probe:*** *Please tell me the 4-7 critical tasks you carry out [as a role: Team Leader, Breacher, Team Member] during a house-clearing mission.*

  The interviewer wrote the response to this question on a flip chart visible to both interviewers and the SME.

- ***Second probe:*** *Of these tasks, which would you consider most cognitively challenging? By that, I mean which tasks require the most judgment, assessment, and decision making?*

  The interviewer circled those tasks the SME identified as most cognitively challenging.

- ***Third probe:*** *What are the decisions involved in these cognitively challenging tasks?*

  The interviewer documented these decisions on the task diagram.

Figure 4 shows an example Task Diagram created during ERT data collection.

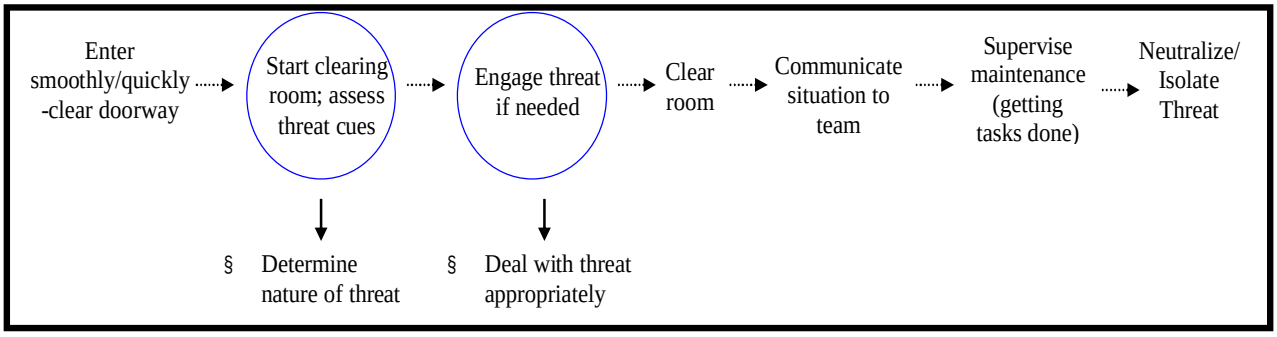


Figure 4. Task Diagram of house-clearing mission.

As shown in Figure 4, this SME noted seven tasks involved in house-clearing missions. Of those seven, *start clearing room; assess threat cues*, and *engage threat if needed* were marked as the most cognitively challenging. *Determine nature of threat* was noted as the key decision involved in assessing threat cues, while *deal with threat appropriately* was associated with engage threat if needed. It is important to understand the nature of house-clearing tasks at this level. When preparing training, developers want to target not only high-level tasks, but also the lower-level decisions necessary to executing those tasks successfully.

Each interview resulted in a diagram of the cognitively challenging house-clearing tasks. Analysis and synopsis of these diagrams is discussed in the Analysis section.

In addition to giving us a view of the critical tasks, the Task Diagram served as a starting point for the Decision Requirements Exercise. By identifying key decisions through the second and third probes, we could begin to elicit critical cues associated with these tasks.

Decision Requirements Exercise (DRX)

After identifying the critical house-clearing tasks, those tasks were placed on a Decision Requirements Table (DRT). The DRT format is used to decompose and represent data on judgments and decision making. It organizes detailed data to provide insight into how tasks are similar or different in terms of the cognitive activities involved. The DRT leads to effective

training applications by decomposing the key decisions involved in proficient performance and providing direction for training development.

The DRT breaks down critical tasks/decisions (identified in the Task Diagram) into five columns:

- **Critical Decision:** The cognitively challenging decisions identified in the Task Diagram interview
- **Factors:** Background information known before engaging in the task/mission that contributes to decision making (e.g., intelligence)
- **Cues:** Information received in the moment or during the mission (what is the performer hearing, seeing, feeling, smelling) that contributes to the operator's situational understanding (e.g., smoke indicates fire in a certain area)
- **Expert Strategies:** Approaches used by experts to achieve a stronger situational understanding and manage a mission more efficiently (e.g., learn the architecture of buildings in the area)
- **Why Difficult:** Ways in which the task may be hard to manage or more challenging for a less experienced person (e.g., we are in the suspect's environment)

The Critical Decision column was populated using the tasks outlined in the SME's task diagram. Subject-matter experts were then asked for information, in terms of decision-making requirements, to populate the columns of the DRT. We elicited this information using the following probes:

- **Factors:** *Tell me what you knew about this situation before you started your mission. This might include information that you get from intelligence reports.*
- **Cues:** *In this situation, or when making this decision, what things were you seeing or hearing that helped you know what was happening in the situation? What was happening in the moment?*
- **Strategies:** *What are the ways that you have learned to work smarter in these types of situations? What things do you do that a less experienced person or other member of your team may not?*
- **Why Difficult:** *How might this situation or decision be difficult for a less-experienced person? How is it difficult in general?*

As SMEs provided information for these columns, they were documented on the table. Table1 shows a portion of a DRT generated during one SME interview (this DRT is drawn from the Task Diagram shown in Figure 4).

Table 1

Example DRT for Threat Assessment and Engagement

Critical Decision	Factors	Cues	Strategies	Why Difficult
Determine nature of threat	• In the North country everyone has a knife or rifle	• Look at body language – are they standing with their hands behind their back? – are their hands under the table? • What is the position of the furniture; is it pulled away from the wall to create a hiding place? • When a team member engages a threat, if I hear them repeating orders over and over that means the person is not complying	• I can recognize signs in body language faster	• Adrenaline gets high; people start doing things too fast or not paying attention • You can miss when the enemy is trying to redirect your attention (by talking with you or trying to get you to look in a different direction)

At the end of the DRX we had a collection of DRTs for specific house-clearing tasks providing factors, critical cues, expert strategies, and potential novice errors and or performance challenges for house-clearing missions. The output of the DRX gave us important points to explore using probes from other CTA methods.

Important to collecting critical cue data is getting examples that demonstrate the relevance of those cues in context. While populating the DRTs, we asked for examples of how these cues and other information would be used. This allowed us to understand the relevance of cues in context and how these cues were put together to form a more complete picture of the situation.

Scenario-based Interview

Although we were unable to observe the ERT members participating in an event, we wanted an alternative means of exploring their decision making. The goal of the scenario-based interview is to elicit a broader and deeper range of cues and factors related to decision making by grounding the interview in a series of situational contexts. The resulting data produces sets of cues and factors, and also indicates the relative importance of environmental information, and how particular patterns of cues and factors are interpreted.

The scenario-based interview was conducted on the first day with a full 4-man ERT after all individual interviews had been concluded. The team was divided into groups of two in an effort to explore differences in the way the situation was addressed as well as differences in the information the ERT members deemed important to their decision making. For the interview, we

used a scenario developed through earlier Klein Associates' MOUT research (Phillips et al., 2001). The scenario, *Surprised by an Unexpected Enemy*, is paper-and-pencil based and has low-physical fidelity. Each team was given a map of the environment and the following scenario (a full scenario description and map can be found in Appendix C):

> You are in HMMWVs mounted with M240 machine guns and have stopped momentarily in the deserted town of Timbaka, which consists mostly of one-story buildings. You are currently in a large, one-room warehouse, checking supplies and communicating with the rest of company. The company commander is two kilometers north and had earlier told you that an intel update from the S-2 suggests that there may be a small (no more than squad-size) enemy force in Timbaka. He has directed you to ensure the town is clear, and then catch up with the rest of the company. The time is 2200, and the overcast skies create a darkness that presents the naked eye from seeing more than 100 feet. Fortunately, your unit is equipped with NVGs.
>
> You are inside the warehouse conferring with two of your squad leaders when you platoon sergeant, who is with the security element outside, calls in: "LT, one of my men just observed about eight enemy soldiers milling about in a building down the street. It's pretty clear that they don't know we're here, or else there would be some commotion. The other buildings appear to be deserted, although there's really no way to tell for sure without checking them out. Wait a minute…A couple of them just popped out of the building and went across the street to the school. They are carrying grenades and AK-47s."
>
> "What do you want to do?"

Each two-person team was given five minutes to read the scenario and develop their Course of Action (COA). In addition to reporting on their COA, each team was also asked what information they wanted about the situation to inform their decision making and what cues in the situation were critical to their situation assessment and COA formation. Each team reported on each of these questions in turn. The output of those reports is in Table 2.

During the interview, the SMEs struggled with the context of the scenario. The scenario was originally designed based on interviews with military commanders. While the urban environment may have been suitable, the war environment and strong MOUT focus was not comparable to the missions the ERTs typically perform. Additionally, SMEs were challenged by having fewer team members to call upon and unfamiliar weapon systems.

Interestingly, despite these scenario constraints, Table 2 shows that members of the ERT were not hindered in their ability to identify relevant cues and information to develop their COA, even though the simulated MOUT environment is only loosely related to the environments in which they typically perform. This is a testament to the importance of expertise and the ability to recognize cues and patterns. Although they were in a different physical environment, the decisions they had to make were the same; thus their ability to assess the situation was critical.

This speaks to the importance of incorporating the types of decision-making cues and information identified through this effort to increase the cognitive fidelity of training.

Table 2

Output of Scenario-Based Interview per Group

<table>
<tr><td rowspan="3">GROUP 1</td><td colspan="2">Course of Action</td></tr>
<tr><td colspan="2">§ We want to clear the school, approaching from the SW
§ Our primary entry will be the doorway and the window to the West
§ We plan to use a stealth approach
§ We will wedge the stairwell doors
§ We don’t expect civilians, but if there are any, our contingency will be to use zip ties, identify soldiers and civilians by uniform, and put civilians in a secure location</td></tr>
<tr><td>Key Information for Planning</td><td>Critical Cues for Situation Assessment</td></tr>
<tr><td>§ What are their communication resources?
§ How can we see floor plans for inside the building; what is the square footage?
§ Is there a basement?
§ What are the cover and concealment options?
§ What is the building size?
§ What additional information do we have on the bad guys?</td><td>§ Time of day
§ Sounds of movement, talking, etc. - shows location of enemy
§ Light from open doors
§ Open and closed doors</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td rowspan="3">GROUP 2</td><td colspan="2">Course of Action</td></tr>
<tr><td colspan="2">§ Position a man on the stairwell
§ 1st option: surround the enemy and negotiate them out of the building
§ 2nd option: go in stealth (dynamic if compromised)
§ Clear room to room; end to end
§ Mark rooms that have been searched
§ (If available) use technology to isolate areas/rooms</td></tr>
<tr><td>Key Information for Planning</td><td>Critical Cues for Situation Assessment</td></tr>
<tr><td>§ Can we turn the power off?
§ How can we see floor plans
§ Are there friendlies inside?
§ How long has the building been vacant?
§ Do they use the building to store ammunition and supplies?
§ When was the last time the enemy used the building?</td><td>§ Empty rooms
§ Signs of movement
§ Sounds from team members (orders, calls for backup)
§ Open windows
§ Lights
§ Sounds outside the building (additional people entering)
§ Sounds of closing doors (does the enemy know we’re coming)
§ Mission timeline (emergency?)</td></tr>
</table>

Overall, data collection was very successful in identifying the critical cues house-clearing teams use during mission execution. In addition, we identified other factors and decision requirements necessary for developing effective training.

Discussed in the following section is analysis of the data collected through this effort. Analysis presented insights in several areas: critical cues, Recognition Primed Decision Making (RPD), team process, and training requirements.

IV. ANALYSIS AND REPRESENTATION

As with data collection, it is important to prepare and identify data analysis goals. While conducting interviews, it is often the case that themes and patterns in the data begin to emerge even before the data collection is complete. As incidents are elicited, interviewers can begin to recognize what is most important about performance, decision making, and training in the domain. Such was the case with this effort.

In preparing for data collection, we considered some of the important themes we heard during data collection:

- The richness of cues and mental models
- The high levels of expertise
- Rapid Recognition-Primed Decision Making
- The high level of team coordination and performance
- The dynamics of the environment in which ERTs perform
- Environmental challenges, such as managing the pace of the work and the multitude of cues being processed simultaneously

Findings related to these and other topics will be discussed in the Findings section. However, thinking about these themes earlier helped us with analysis and representation. We were able to identify the analysis methods best suited for uncovering the type of information we were recognizing as critical to this environment, and then use the analysis to build a more complete picture of these themes and processes.

Analysis and Representation Goal

Since the critical cues identified through this effort will be incorporated into training for CFs, we wanted to use the analysis to identify information and training requirements and represent them in a usable format. Thus, our analysis and representation goal was to *identify the decision requirements relied on during house-clearing missions (based on ERT member expertise) to support the development of scenarios to train the recognition of perceptual cues used to diagnose events and coordinate actions during house-clearing missions.*

Following is a description of our analysis process for the Task Diagram interviews and Decision Requirements Exercise (including some critical incident examples). Representations resulting from these analyses, including the Critical Cue Inventory, are also presented.

Task Diagram Analysis

The purpose of the Task Diagram analysis was to identify the cognitively challenging tasks involved in house-clearing missions. To identify these tasks, we used a clustering analysis method, which would reduce the amount of data by categorizing or grouping similar data items together. We did this by comparing all of the diagrams created during individual Task Diagram interviews.

At the end of data collection, we had five task diagrams presenting the range of house-clearing tasks (because of the similarity of tasks, we did not need to elicit diagrams from the last two SMEs). In analyzing these diagrams, we first identified similar tasks. While tasks were not necessarily described using the same terminology, we were able to sort them into specific categories based on the similarity in descriptions. Based on the task description, we assigned a general descriptor to similar tasks (some tasks, like preparation, were stated in the same way by the SMEs and have no clustered tasks). Those tasks, and their assigned categories, were as follows:

• ***Preparation***	• ***Briefing***
• ***Breach/Entry*** – Entry – Accomplish successful breach – Ram door – Enter room by order – Enter smoothly/quickly	• ***Secure room through domination*** – Securing building – Clear room through domination – Movement inside – Start clearing room
• ***Identify targets*** – Complete successful search – Find targets – Assess threat cues	• ***Engage targets*** – Secure targets – Clear room of targets – Neutralize threat
• ***Communicate situation to team***	• ***Report to Commander and Investigator*** – Hand over to Investigator – Report to Commander and Investigator
• ***Debrief***	

Though not all tasks above were noted by each SME, they were still included in the critical task list.

The second level of clustering focused on those tasks that were noted as cognitively challenging (requiring the most judgment, decision making and assessment). Three tasks consistently emerged as cognitively challenging: *secure room through domination*, *identify targets*, and *engage targets*.

Figure 5 shows the final Task Diagram based on this clustering. This figure represents the nine key tasks involved in house-clearing missions in the operational order in which the SMEs presented them. The three cognitively challenging tasks are highlighted.

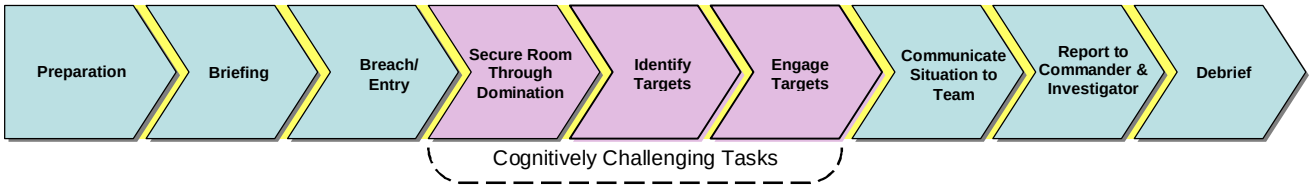


Figure 5. Primary and cognitively challenging house-clearing tasks.

Training for house-clearing should target the above key tasks necessary to successfully executing these missions. To do this effectively, trainers must understand the information requirements for each task. This is accomplished by identifying the critical cues associated with relevant tasks. This information came out of the analysis of Decision Requirements Tables.

Decision Requirements Tables (DRT) Analysis

The decision requirements analysis identified the cognitive elements, including cues, factors, expert strategies, and why difficults. These elements were captured in the interviews while SMEs told about their experiences, and later catalogued into lists of frequently occurring and critical cognitive elements. As an example of how the stories were told during the interviews, and how cognitive elements were identified and extracted, we have annotated one of the incidents in Figure 6. This figure shows the richness of the cognition involved in house-clearing tasks, and illustrates how we distinguished cues, factors, strategies, and why difficults during the course of the interviews.

Two interesting insights are gained from this incident. First, it shows the importance of factors in decision making. This SME had a very rich understanding of the building structure and how to use those structural elements to support mission execution. He used large windows as a leverage point to clear the room from the outside before entry. His understanding of how plantations are run (many barns means they employ many farm hands) led him to look for additional cues to increase his understanding. Adding this type of information to any training scenario can help trainees begin to hone their ability to make connections between the knowledge they bring to the task and what is happening around them to build a more complete situational picture.

The second insight from this incident is how the expert creates meaning from what seem to be subtle cues. Recognizing the low windows and the chimney near the ground as cues to conclude that there was a basement that served as a living space is a good example of how an expert can piece together bits of information to form a complete understanding.

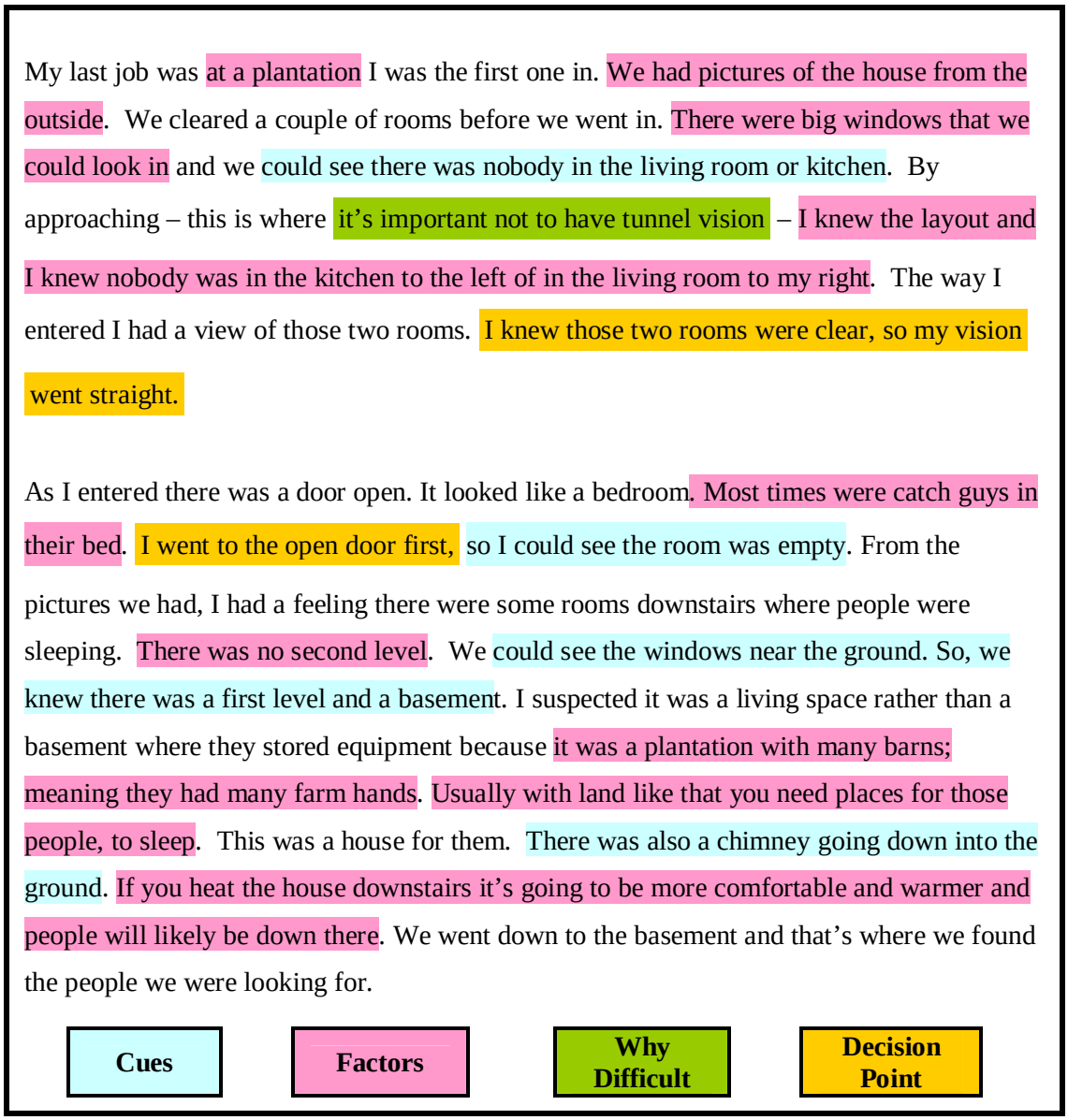


Figure 6. Annotated critical incident.

As stated, the incidents were broken down into their cognitive elements during the course of the interviews, in conjunction with the SMEs, using the DRT structure. The DRT itself acts as a pre-analysis tool because it deconstructs what experts notice in their operational environment and categorizes that information while it is being elicited. The DRT columns provided a good starting point for grouping critical information to create a cue inventory.

House-Clearing Critical Cue Inventory

The purpose of the DRT analysis was to identify the themes and patterns in cue recognition that characterize expert situation assessment in house-clearing. We also applied clustering to analysis of these data. Our criterion of how to cluster the data was based on the research goals. The primary focus, and deliverable, was a Critical Cue Inventory (CCI) highlighting the cues and information house-clearing teams use to make situation assessments. To this end, we reviewed the *Cues* column of the DRTs to begin to identify recurring cues that could be clustered into individual groups. We did this with two passes through the cue data. First, we each reviewed the DRTs and identified those cues that could be grouped together based on the terms used to describe the cues and the context in which the cues were perceived. We then discussed and reached consensus on those categories. Cues that were presented as part of a specific incident were generalized and grouped with other cue categories. For example, in one SME incident, he stated that he saw someone looking at them out the window. This was an indicator to him that their stealth approach had been compromised because the inhabitants of the house knew they were coming. While this cue was told within a specific context, it is transferable across situations and contexts.

After this first pass through the Cues column, we had grouped the cues from each SME's DRT. This analysis showed that all of the cues fit within four main groupings:

- **Environmental Assessment Cues:** objects that exist in the operational setting and pose a potential threat to the team or its mission or provide leverage points for the "badger" (SME term used to describe the threat or "bad guy")
- **Threat Assessment Cues:** anything that poses an immediate danger to the safety of the team or its mission
- **Situational Assessment Cues:** visual, verbal, and tangible indicators existing in the operational environment that individuals use to build an understanding of the whole situation, i.e., to build a "Big Picture" view. These indicators allow the decision maker to consider how different situational elements fit together and affect each other
- **Team Assessment Cues:** visual, verbal, or tangible indicators that allow team members to assess and or determine each other's stance and situational dominance

Our second pass through the cue data was to see if the previous cue groupings still held up against the four defined critical cue categories. For example, we wanted to make sure the cues that we grouped together because they were all indicative of developing an understanding of the situation fit within the Situation Assessment Cue category and definition. This served as a cross-check of our analysis. Since the cue categories were defined based on the original groupings, it should be expected that we could match the original groupings to the cue category and definition they influenced. If we were unable to make a simple one-to-one match between the individual cue and the category, we discussed the aspects of that cue that made it part of one category versus another. One such discrimination had to be made between the *cues*, "If I have to keep repeating the same thing it means the 'badger' won't comply," and "When my team member engages a threat, if I hear them repeating orders over and over that means the 'badger' isn't

complying." Originally, both of these cues were put in the same group because they were specific to identifying and engaging a threat. However, the important discriminator is what part of the threat situation was being assessed. In the first cue, the SME is assessing his impact on the threat he has engaged. Because he has to continue to repeat his orders it indicates to him that the "badger" is not going to comply. This could influence his decision to change his tactics or call for backup. In the second cue, the SME is listening to his teammate's verbal cues to know whether or not his teammate has control over his area of responsibility. This information could influence this SME's decision to remain in his own area or go to his teammate to provide support. After this assessment, the first cue was placed in the threat assessment cue category, while the second was placed with team assessment cues. This proved to be an important discrimination in the development of the cue inventory. It should also serve as an example of important distinctions to make in training the recognition of such cues.

The outcome of this analysis is a Critical Cue Inventory (CCI) representing the critical cognitive cues that must be recognized and processed to effectively perform in house-clearing missions. These cues are based solely on our interviews with ERT members. However, the strength of these cues is that they are specific to house-clearing missions, not RCMP ERTs. They are important in evaluating the environment, threats, and situations in which forces operate. Further research with additional ERTs, Canadian Forces, or other military entities will most certainly provide additional cues to augment this inventory. However, this early representation serves as a strong first step in identifying, incorporating, and transferring (through scenario-based training) expert performance requirements. The Critical Cue Inventory can be found in Table 3.

As stated in the Task Diagram Analysis section, being able to train to perform critical tasks involves incorporating the cues associated with that task. One of the critical tasks identified in Figure 3 is Identify Targets. Essentially, this task is about determining who is a threat to individuals and to the team. Training for this task should incorporate cues from the Threat Assessment category since these cues were identified as those that allow team members to determine the existence of immediate danger to the safety of the team or its mission. Using cues from the CCI in this way (in conjunction with the Task Diagram) is how training scenarios with effective levels of cognitive authenticity are developed.

Table 3

Critical Cue Inventory

Environmental Assessment Cues

Objects that exist in the operational setting and pose a potential threat to the team or its mission or provide leverage points for the "badger"

- Size, shape, layout of room
- Spatial relationship/setup of furniture
- Hinges on door open inward or outward
- Lighting
- Hazards, such as booby traps
- In or near a kitchen—where are the natural weapons
- Dangers to life (gas leaking)
- Razor wire on tops of walls
- Terrain dictates support (high buildings or brush to support snipers, room for surveillance
- Indicators of a barricade
- Broken glass
- Reflection of a camera lens to know if suspect is observing us and our movement (pre-entry)
- What material is the furniture made of (can they or we shoot through it)
- What material is the furniture made of (can they or we shoot through it)

- Carpet or linoleum floor, materials we could slip on during clearing
- Cubby holes, closets (hiding places)
- Number of windows
- Size and construction of doors
- Look for people in the room
- Blind spots in the room (e.g., corners, tall furniture)
- Open doors (never walk past an open door)
- Watch the window to see if people are watching you
- Look for signs of activity upon approach
- Windows or visible light
- Windows near the ground is a sign of a basement
- Chimney going down to the ground (if you heat the house downstairs, it will be more comfortable and warmer for people to be down there

Table 3 (Continued)

Threat Assessment Cues

Anything that poses an immediate danger to the safety of the team or its mission

- Look at person's hands (I want to see them VISIBLE and EMPTY)
- "Badger's" body language (clenched fist, thousand-mile stare, hands under table)
- Timelines (how long have they been in the house)
- Dogs roaming on the property
- People peeping out the windows
- Monitor body language
- Objects on table that can be used as weapons (e.g., knife, screwdriver, gun)
- Officer has to keep repeating the same thing—"badger" won't comply
- Don't want badger moving, pointing, screaming, holding anything in his hands
- Look for reflections of weapons (like chrome of gun)

- "Badger" positioning feet in a combative stance (are they positioned in a way that can give them leverage)
- Watch to see what "badger" is looking at
- What is the reactionary gap—is there enough space for them to jump me
- Is the person trying to close the reactionary gap through conversation
- Is the person trying to misdirect my attention
- If the door is closed I can't see in the room… don't know what's happening behind it
- Is the suspect looking right at us or turned away from us (could give us a leverage point to jump him)

Table 3 (Continued)

Situation Assessment Cues

Visual, verbal, and auditory indicators existing in the operational environment that team members use to build an understanding of the whole situation (i.e., to build a 'Big Picture' view). This allows the decision maker to consider how different situational elements fit together and affect each other

- Time of day (what does the person typically do at this time, indication of where they may be in the house)
- Is there a landline or cordless phone (can they walk around while we talk with them or do they have to stay stationary)
- If the person is huffing and puffing while talking with negotiator it means they're walking around
- Is "badger" getting information from the media
- Is the population gathering at the event (this is an indication of how typical this person's behavior is. If people are coming around, it's uncommon and may be more dangerous… if they are staying away and not paying attention, it's more of a regular thing. They're thinking, "he's at it again")
- After breach, the space between me and the door helps me determine if I should go in with the door

- How commander is acting when I arrive at scene (body language…hands waving means things are unorganized, too cool means they're overconfident and think of it as "just another event"
- Team members running into position is a sign of preparation
- Noise… talking, TV, radio…helps you locate the "badger"
- If you are on the first floor, you need a certain amount of stairs. If you come to the first floor and there are only four stairs it is not high enough to indicate a second level
- As the first guy I want to know about the positions of the door
- We need a lot of details that a normal person wouldn't know to tell us like small things I want to know (beer bottles on the floor)

Table 3 (Continued)

Team Assessment Cues (for Team Leader)

Visual or verbal indicators that allow team members to assess/determine each other's stance and situational dominance

- Watch the level/height of the POLICE sign on back of body to interpret body language
- Watch the letters on the back of the helmet to see if it stops moving as an indicator of a guy becoming focused on one thing and no longer scanning
- Look at numbers on back of helmet to know where guy is looking
- Guy stops scanning situation and becomes focused on one thing
- Tone, volume, agitation, voice is breaking up

- Hear officer repeating the same thing (Stop, Police, I want to see your hands!)—know they aren't getting compliance
- No talking may be a warning that a problem might be imminent
- Team member's aggressive body position (crouched, karate stance could indicate guy is ready to fight)
- If I see them backing up it might indicate a fight is imminent (usually within five seconds)

Team Assessment Cues (for Team Members)

Cues team members observe in one another to assess the team's stance and dominance

- See team members not reacting to obvious threat areas (e.g., not covering stairs)
- Hear team member say, "I'm moving"
- Hear team member call for backup
- Notice a developing situation that the team member is unaware of (cue to provide backup)
- Team member taps me on the shoulder so I know he is there (I don't have to look behind me)
- Listen for cues that indicate team member is dominating the room—tone and volume of voice
- When team member engages a threat, if I hear them repeating orders over and over that means the "badger" isn't complying

- If I don't hear my teammate or the target talking at all, that can be a negative
- If I see a gap in the team formation to jump in after I breach the door and grab my gun, I'll go
- The speed of movement of the team going in helps me assess the gap in team formation and know when to jump in
- If the team sees me ram the door and go in they know to start moving in around me. You don't want to get between guys and slow the team down. It's like a chain reaction

Factors, Strategies, and Why Difficult

The information in the Factors, Strategies, and Why Difficult columns serves to enhance realism and modulate level of difficulty.

Factors are those pieces of information known prior to engaging in the task or mission that contribute to expert decision making (e.g., intelligence). Training developers should determine how much of this information they want to provide to the trainee. More background information might accompany an easier scenario, while providing less information will challenge a trainee to fill gaps to make decisions or seek ways to obtain desired information. In analysis of the ERT DRTs, we highlighted factors that were noted across SMEs as important to their decision making:

- Time of day
- Number of people in the residence
- Timelines in terms of the mission execution and intelligence on the target (how long have they been in the house)
- Intelligence on the enemy and their weapons
- How many levels the building consists of
- Is it a residential building or apartment?
- Familiarity with the area (e.g. in the North country everyone has a knife or rifle)
- Weather (this can impact the way the team is staged during breach)
- What resources are available to the team
- Do I have the ability to cut off the gas and phone lines in the house?
- Mental and or physical condition of the suspect
- Is there an undercover agent or informant in the residence?

Strategies are those techniques used by experts to achieve a stronger situational understanding and manage a mission more effectively. They may also reflect the expert's tendency to weigh some cues with more significance than others. For example, information about the environment that is provided by an informant or residence of the house (e.g., the back door is a safe entry point) may not always be taken with full confidence. Why? Because there may be elements in the environment that are not seen as relevant by someone who does not perform house-clearing missions. The door that they identified as safe to enter through may be surrounded by bottles which, if the team comes across, will serve as an alarm to the "badger." As one SME noted, "we need a lot of details that a normal person wouldn't know to tell us…small things I want to know, like there's beer bottles on the floor."

Strategies often include resources experts use to improve their knowledge of the situation, such as becoming familiar with the history of the community in which they will perform and knowing the age of the buildings they will be entering. This gives them knowledge about where phone and gas lines may be located, if a basement may be included in the house, or how the door is constructed or hinged. Essentially, the expert is using resources in the environment as leverage points to improve his understanding. Training developers can incorporate these same resources to evaluate the trainee's ability to recognize them as potential

leverage points. Analysis of the Strategies column identified the following strategies experts employ in this environment:

- I plan for the ideal situation and also develop contingencies at the same time
- I get the suspect to talk…it's proven that if the suspect is talking, he can't shoot
- Don't always assume the target is in the room where the noise is
- I know when I get information from the Investigator to have doubts and seek additional information
- (After breaching) If I see a gap in the team formation to jump in after I grab my gun, I'll go
- I go to the open doors first, so I can see if the room is empty
- I do my own reconnaissance and take pictures of the location
- If the house is listed for sale, I go on the internet to see pictures of the interior
- I look for high-resolution satellite images from maps on the web
- I do things to maintain an element of surprise (like create a distraction with a fake delivery or flash bangs and smoke)
- In extreme cases, we come through the side of the wall instead of the door if they expect us
- If I close the reactionary gap it gets people to comply with my orders
- I have the suspects keep their hands high in a way that they must make large movements to be a danger
- I focus on known areas and prioritize the biggest threat
- I dominate the area upon entry (get loud and in the suspect's face)
- I watch the surrounding population to see how they are responding to the situation (are they gathering around because it's an uncommon occurrence or ignoring it because it's a common incident)
- I learn the architecture of the buildings in the area
- I create options for mission planning while doing analysis

Why Difficult describes those ways in which the task may be hard to manage or challenging for less-experienced performers. Adding fewer or more of the elements from the Why Difficult column can increase and decrease the complexity of training scenarios. One example of why house-clearing missions are difficult is because loud noise, such as the TV or radio, can make communication difficult. Adding this type of challenge begins to alert trainees to the complexity of the environment they will be expected to perform in, and push them to use tactics and resources flexibly to maintain communication.

Elements of difficulty in this domain are manifested in two forms: things that make performance in house-clearing missions difficult, and errors that less-experienced operators tend to make during these tasks. We analyzed the Why Difficult column according to these two categories.

Why Difficult: Mission Execution

- Fatigue
- There's massive information overload in dynamic missions
- We are in the suspect's environment
- Heavy, bulky equipment makes movement difficult
- We have to clear the room as quickly as possible to maintain the element of surprise; otherwise we have to change tactics to clear other rooms
- Team members aren't part of the community; they haven't learned the area
- There are hiding spots and booby traps
- We have to find the target before he can take action on us
- Loud noises in the environment can make communication difficult
- There may be others in the house (like the target's wife and kids)
- If there are barricades up, you lose the element of surprise and have to re-evaluate the situation
- Hostages complicate the situation
- The situation changes in a lot of jobs (e.g. outside we think the kitchen is on the right and when we get into the building it's on the other side, so we have to adjust)
- Need a tactical mind…we need the ability to adjust quickly to a stressful situation and be able to do several things when running through the building

Why Difficult: Potential Novice Errors/Challenges

- Get overwhelmed with all the information
- Can't manage the constant and quick analysis
- Don't pay attention to key components of their task
- Not paying attention to the surrounding environment
- Get apprehensive because of time crunch
- Experience peer pressure of doing the best job and not letting the team down
- Don't recognize or focus on the threat
- Get tunnel vision/hearing
- Have a lack of decisiveness
- Adrenaline gets high; people start doing things too fast or not paying attention
- Miss when the enemy is trying to redirect his attention (by talking with you or trying to get you to look in a different direction)

While information on what complicates a house-clearing mission can be used to alter scenario difficulty, it can also be used to identify training objectives. The potential errors presented here were elicited from expert performers. Most likely, those experts made many of these errors when they began performing house-clearing missions. Over time and multiple experiences, they identified procedures to avoid these errors by applying their expertise. Now they recognize the presence of those errors in new trainees. Eliciting and utilizing this type of information can help developers more directly target specific performance gaps.

Team Performance

Because the house-clearing task is dependent upon team performance, it is important to understand the processes teams employ. The data from the critical incidents revealed three key team dynamics in the house-clearing mission.

1. *Thinking and performing independently within the team is a baseline skill.* This is guided by low task interdependence. Team members need to manage their own area of responsibility. This means that they have to make the situational and threat assessments necessary to clear their area. Their role, as a member of the team, is to ensure their area is clear and does not pose a threat to the team or its mission. It is important to know what is happening in their team members' areas but, as one SME stated, "Your only job is the objective. The objective is not to be with Buddy. My objective is to back Buddy, not to *be* with Buddy. If Buddy falls down going up the stairs, I'm going past him."

2. *Recognizing team cues is critical.* Each team member has a responsibility for his objective, but, when he has secured his area his attention goes to supporting his teammates. Room clearing and reaction to what other team members are doing happens simultaneously. They listen to what their team member is saying to the suspect in the room (while checking other areas of the room) and the suspect's response. "When I'm moving through the house and hear a teammate scream 'Police!' you know they just found someone. When I clear my room I won't continue to search the house, I have to go to that teammate to back him up. If he has a backup when I get there I'll go back to somewhere where I can be more useful."

3. *Trust plays a major role in team performance.* Because ERT teams select their own members and participate in missions together, they have many opportunities to build trust. Team members trust one another to cover and effectively clear their area of responsibility. They trust their team member's ability to compensate and fill a gap in the team (e.g., if one team member is not covering a threat area, someone will step in to fill that gap). This trust also contributes to the low task interdependence (they each implicitly trust that the other team members are doing their jobs in their areas and so have no concern to step away from their assigned areas to support another unless needed).

Training Needs

It is valuable to get an expert's opinion on the dynamics of his job and the type of training required for less experienced performers in their domain. The critical incidents revealed several things about training needs for house-clearing tasks.

1. *House-clearing skills are perishable.* Several SMEs stated that because they do not have the opportunity to do these missions often enough, the skills necessary to perform these tasks can become degraded. As one SME stated, he was surprised by how easily he succumbed to tunnel vision after months of not participating in a

mission. It can take a bit of ramp-up time, even for an expert, to be as reactive as they need to be after being away from the task for a while.

2. *Fifty percent of their job is about making adjustments.* New candidates are evaluated on their ability to adjust their movement and do it very quickly. Experienced performers can recognize this deficit in new recruits. Because we conducted interviews while our SMEs were instructing the Selection Course, we got examples of what they were looking for. One example reflected this performance need: "Imagine going into hallways where there's a lot of turning. Some guys just cannot do it. Some people were turning off balance; they were turning left when we said right. They weren't turning towards the target. Right now, the training is turning and shooting. He's in a controlled area and he turns left when I say turn right. By experience I know I wouldn't trust him as a backup. He's a good cop, but tactically he doesn't have it."

3. *Cross-training is important in this environment.* The dynamic situations these teams perform in often call for shifts in role and responsibility. In one example, an SME described an incident in which had defined him as the Breacher and the first one in the room. However, after he breached the door, because he had nowhere to immediately throw the ram, he had to step back and let the others enter; making the original second person the first person in and the Breacher had to get in when there was a gap in the formation. Because they cross-train to each other's jobs, each of the team members can fill multiple roles when needed. Without cross- training, the teams would not be able to support the role transition and shifts necessary to complete their tasks.

4. *Using Standard Operating Procedure (SOP) flexibly is critical.* It is clear that training house-clearing procedures is important. These procedures include checking all rooms and corners upon entry and always taking no fewer than two people to clear each room. However, the incidents showed instances where this foundation had to be used more flexibly. One such example: "We work differently than the training program. There's the practice and then the way we work. We all start with the same basic information—walk into the house, clear the corner, and don't walk in front of an open door. But if we do all of that, by the time we get to the second floor and the bedroom, we have been in the house for three minutes…the target is awake. Now we're putting ourselves in harm's way."

These points not only represent potential training needs, but performance challenges that can greatly complicate mission execution and personnel safety. In the Implications for Training section we describe the use of cognitive-based training scenarios to fill these gaps.

Following is a discussion of the key findings that emerged from this analysis.

V. FINDINGS

Analysis of the CTA data generated four categories of findings. The first two categories, critical cue recognition and decision-based training, are directly related to our three research objectives (See Executive Summary, p. ii). The other two categories address important findings identified during analysis. Specifically, we discovered that house-clearing teams rapidly shift between RPD and SOP and that there is a unique balance in the way teams perform. Each finding is discussed below.

Critical Cue Recognition

***Finding 1*:** Critical cue recognition is a foundational skill for house-clearing

As the Critical Cue Inventory (see Table 3) illustrates, there are a multitude of cues house-clearing teams are responsible for recognizing and making sense of. Expertise involves the ability to recognize cues and create patterns and stories that describe what is happening in the situation. In this environment, experts are balancing the rapid reception and interpretation of cues about the threat, environment, situation, and team. These cues also have valuable relevance in terms of role and function. The majority of the critical cues in the CCI will be consistent regardless of role. These include the layout of the room, the setup of furniture, the time of day, hazards such as booby traps, and verbal team member cues, such as calls for backup.

Some cues may be more relevant to the Team Leader, such as the team cues he observes (e.g., from the outside of the space, he watches the letters on the back of the member's helmet to see if it stops moving. This is an indicator that the member is becoming focused on one thing and no longer scanning the room. The leader uses this information to determine if the team member has engaged a threat). Other cues may be more specific to the Breacher (e.g., looking to see if the hinges on the door open inward or outward. This will determine the best method for breaching). Others, however, are representative of the general expertise house-clearing SMEs have developed through multiple experiences. For example, while the training received regulates that team members enter the room in formation and check their assigned areas in each room, SMEs mentioned that there are cues that will encourage them to deviate from this SOP. For example, if the operation is taking place at 3:00 am, the chances are high that the suspect will be sleeping in the master bedroom. Therefore, they will go directly to the master bedroom after breaching. In this situation, clearing other areas of the house seems unnecessary and may compromise the remaining element of surprise. In terms of team assessment cues, all SMEs noted the tone or volume of their team members' voices as an indicator of whether they are dominating their areas (have the area cleared or have the suspect under control). However, only two SMEs noted that a negative cue would be if they didn't hear their team member or the suspect talking at all. This would suggest a potential problem in that team member's area of responsibility.

Training for house-clearing missions has to present this mix of cues to appropriately prepare new team members. The ability to pick up on and monitor all of these cue types is critical. Performers who are skilled at noticing environmental cues, but lacking in their ability to recognize threat cues will likely put themselves, and their team members, in situations that

endanger their lives. Training that only addresses one to two categories while ignoring the others will likely be more detrimental to performance in this environment than helpful. Incorporating these cues into instructional scenarios will be further discussed in the Implications for Training section.

Training Needs

***Finding 2*:** Effective training should present trainees with situations that instruct them to use their perceptual skills to assess the environment to appropriately apply tactics

The data indicate a difference between how house-clearings are currently trained vs. how they actually occur on the job. While mastery of SOP and tactics is critical for good performers, training can be augmented to improve its cognitive fidelity and decision challenges. The argument should not be made that intuition should be used as a replacement for procedures. On the contrary, when people develop situation-assessment skills, they also become smarter about what tactics will work to mitigate particular situations and apply those tactics more appropriately and flexibly.

Current training tends to focus primarily on SOP. Basic training exercises are often conducted in an empty room and are made more difficult by adding furniture and people. These exercises develop the novice's ability to maneuver in the physical environment and identify potential obstructions and threat areas (e.g., tall bookshelves or closed doors). However, this training does not often incorporate the types of perceptual skills experts have learned throughout their years of operation.

It is understandably necessary to provide new recruits with a foundation of SOP for how to conduct house-clearing missions. However, it is evident from the data that perceptual, decision-making skills are critical to both individual situation assessment and the team's ability to cohesively and adaptively complete their missions. The expectation is that training will provide a procedural foundation and, through operational experiences, performers will develop the ability to make perceptual judgments. However, as it has been shown in the training literature, *knowing* about patterns and *using* patterns are two different types of knowledge. Since expert decision-making processes exist as tacit knowledge, one cannot "learn about" decision making to increase expertise. One must practice making decisions (Ross, Lussier, & Klein, 2005). The way knowledge is learned determines how knowledge will be used. Thus, training should present situations that encourage trainees to perform in the way they would be expected to in the operational setting. As this effort has shown, that means not only including physical maneuver challenges, but also decision-making and assessment tasks.

Developing scenarios to address this training to performance gap will be further discussed in the Implications for Training section.

Recognition-Primed Decision Making vs. Standard Operating Procedure

***Finding 3*:** House-clearing involves a dynamic exchange of RPD- and SOP-based decision making

In Section Two of this report, we described the three variations of the Recognition-Primed Decision Model (Figure 1). Decision making in the house-clearing environment is dynamic and rapid. Experts in this environment make quick assessments and, based on their judgments, apply appropriate tactics. This occurs with entry, when assessing the environment, when encountering someone and determining if they are a threat, and when selecting the most appropriate way to engage the threat. All of these judgments happen in a matter of seconds or in fractions of seconds, not minutes. Because of this, decision making in this environment involves an interesting mix of all three variations of the RPD model and SOP. What the data show is that these cognitive and procedural processes are so entwined that they can be difficult to separate.

The SOP that Emergency Response Teams use is a tightly scripted set of actions. For example, in the pre-entry phase of the house-clearing mission, snipers move into position, additional intelligence is gathered, and the team prepares for breaching. This is characterized by SOP and Variation 3 of the RPD model. The ERT uses SOP for choosing where to park the vehicle, selecting sniper locations, where to place the stack, and how to breach the door. If features in the situation are significantly different than what was briefed (e.g., the planned entry route into the house is unavailable), the team will use Variation 3 decision making to adjust their course of action by imagining how a potential course of action will play out using mental simulation. If the decision maker anticipates difficulties with the course of action, they reject it and look for another option before executing the mission. Although these pre-entry decisions and actions are performed with alacrity, they are less rapid than the decisions and actions taken during room entry and clearing.

Variation 1 and Variation 2 characterize the decision making in the room entry and room clearing phases. Here, team members make a series of very rapid decisions without imagining alternative courses of action. When entering a room, the team uses an SOP. The first person in turns right or left to clear their corner of the room, and each subsequent team member keys off the movement of the person before them (going in the opposite direction) to clear their area. These actions taken during the room entry phase are predicated in an SOP and are not based on recognition-primed decisions. Consider, however, the possibility that upon entry, the first person in the stack encountered someone standing in the room. What was SOP can suddenly become a Variation 3 of RPD. The first team member in the house who encounters this person must assess the distance between them and if this person is exhibiting cues that indicate a threat. Based on those judgments, he must decide whether to continue with their standard movement to the right or left or to engage the threat. At the same time, he must consider the rest of the team staged at the entrance and how his immediate action may impact the team as a whole. All of this must happen in a matter of seconds. If the team member takes too long to respond it will slow down the team and jeopardize the mission. This example represents the rapid shift in SOP and RPD that can repeatedly occur in this environment.

The following incident captured during a data collection interview illustrates how the ERT moved seamlessly between using SOP and the RPD variations to make decisions in a real house clearing mission. In this incident, the ERT was given the mission to secure a suspect who was known to be armed and dangerous (he had boasted to a police informant that he would not hesitate to shoot the police if they ever came to arrest him). The police informant told the police that the suspect lived on the second floor of an apartment building whose back door stayed unlocked. The ERT surveyed the building the day before the mission to collect their own intelligence.

The ERT holds a brief before each mission in which the Team Leader shares mission goals, plans, background information, and the most current intelligence about the suspect. The group clarifies its understanding of these things and offers ways to improve the plan. During the brief for this mission, the ERT learned that the suspect went to bed at 11:00 p.m. the previous evening, that they would use a stealth approach, and enter the building through the back door (even though the suspect used the front door exclusively).

At 6:00 a.m. when the ERT arrived at the suspect's apartment building, the team did not notice any signs of activity in the suspect's apartment. They approached the building, found the back door unlocked, formed into a six-man stack, and quietly entered the apartment building as planned. The decision to go through the back door is an example of SOP. The plan for how to approach and enter the building was conveyed in the mission brief, and the team followed a tightly-scripted set of actions understood by all team members.

After going through the unlocked back door, the ERT proceeded up an interior flight of stairs they thought (based on intelligence) would lead to the suspect's kitchen on the second floor. However, after going up 10 steps the team encountered a second door in the stairway, which was unexpected. At this point, the Breacher called a halt. The stairs had not led to the first floor as he expected. He did not know what was on the other side of the second door, and he was uncertain where he was. Was he on the first floor? Was he on the second floor? Was he between floors? He recalled a similar incident from the previous year in which the team came out on the wrong floor when using an interior staircase. Because his expectancy had been violated (not seeing a first floor landing and encountering a second door), he decided to discuss the situation with the Team Leader. His decision to do more diagnosis of the situation and pursue another course of action is an example of Variation 2 of the RPD model.

The Team Leader and Breacher decided to turn the team around and consider breaching the front door. They looked at the front door and discussed the best way to enter the building. They imagined how alternative courses of action might play out and eventually decided to enter the building by ramming the front door. The decision to ram the front door after assessing the situation and mentally simulating potential courses of action is an example of Variation 3 of the RPD model. The team evaluated a single option by imagining how different courses of action might play out and settled on a plan that seemed workable.

After breaching the front door, the team advanced up a short set of stairs and the Breacher rammed the door to the suspect's apartment. The suspect was sitting in the living room when the Breacher rammed the door. The number one and two members of the stack

moved swiftly by the Breacher and went into the apartment. The Breacher spotted a small gap in the stack and slipped into the number three spot in the stack and rushed into the apartment. The suspect went into the bedroom to get his gun as the team entered the apartment. The suspect retrieved his gun and began to re-enter the living room, but had not turned his head toward the ERT members yet.

By this time, the second man in the stack was close enough to the suspect to grab the gun while it was still in the suspect's hand and push him backward into the bedroom. The Breacher was right behind the second man and knocked the gun from the suspect's hand. The Breacher and the number one and two men secured the suspect while numbers four and five in the stack secured the suspect's girlfriend who was in the living room.

The team made a series of very rapid decisions without imagining alternative courses of action because they recognized the situation as typical and familiar. The ERT knew what cues were important, the types of goals that made sense, and typical ways of responding in the situation. By recognizing the situation as typical, the number two man recognized that he was close enough to the suspect (important cue) that he could grab the gun to disarm the suspect (typical way of responding) instead of shooting him. This decision allowed the team to minimize injury to the ERT and to the suspect (a goal that made sense for this situation).

Table 4 presents the critical cognitive components and the mix of decision strategies used by the ERT in the incident described above.

Table 4

Mix of Decision Strategies Used by ERT in a Single Incident

Decision Points	Description	Decision Strategy
Decision Point 1	Enter the building through the back door	SOP
Cues	No signs of activity in suspect's apartment; nobody in back of house	
Factors	Intelligence report says that back door is unlocked; mission brief specifies entering building through back door.	
Expectancies	A stairway behind the door that leads to the suspect's apartment on second floor	
Goals	Use stealth approach to surprise the suspect and complete the mission without injuring the ERT or the suspect	
Decision Point 2	Not to go through a second door at the top of the stairs	RPD Variation 2
Cues	Door was in an unusual location; didn't know what was on the other side of the door; hadn't gone up enough stairs to have reached next floor	
Factors	Breacher recalled similar incident where ERT came out of stairway onto wrong floor; may have to ram door and make a lot of noise; suspect willing to shoot the police	
Expectancies	Ramming door would alert suspect; team is spread out down the stairs and it will take them longer to get through the door	
Goals	Maintain stealthy approach and remain undetected until they breach the suspect's apartment door	
Decision Point 3	Go through the front door	RPD Variation 3
Cues	Suspect used front door all the time; front door is a story higher than back door	
Factors	Had better sense where they would be in the building after ramming front door; discussed potential courses of action	
Expectancies	Find stairs leading directly to second floor and suspect's apartment door	
Goals	Get entire ERT into the suspect's apartment as quickly as possible	
Decision Point 4	Knock gun from suspect's hand	RPD Variation 1
Cues	Suspect went to bedroom to retrieve gun; suspect's head wasn't turned toward the ERT as he re-entered the living room	
Factors	ERT member was so close he could grab the suspect's gun	
Expectancies	ERT team member could engage suspect before he could get shot off	
Goals	Secure suspect; not shoot suspect if he can be disarmed first; keep ERT safe	

This scenario offers a rich example of the RPD and SOP exchange experienced in house-clearing missions. Training this type of processing and maneuvering is not easy but is necessary. Those operators who rely solely on SOP in these types of situations risk committing many of the performance errors identified in this research; such as the inability to manage quick analysis or having a lack of decisiveness. Critical cues also become highly relevant at this stage of performance. Through recognizing cues that indicated a change in the situation the SME in the above incident was able to redirect his team and use standard tactics more flexibly. As trainees become more skilled at identifying and understanding the relevance of situational cues they will be better able to determine when it is appropriate to maintain SOP and when to deviate from those procedures.

Team Process and Performance

***Finding 4*:** Successful team performance in house-clearing requires fluid transitions in coordination and collaboration

Introduced by Zsambok, Klein, Kyne, and Klinger (1993), team conceptual level describes the notion of the "team mind." Teams with a high conceptual level work as an intelligent entity to solve problems, make decisions, and act collectively to complete tasks. High performing teams leverage this collective mind to (among other things) establish clear goals and plans and to ensure that all members share a common understanding of the situation. The house-clearing teams we interviewed exhibited high team conceptual levels. They have a clear understanding of their team and mission goals and their role in accomplishing that mission. Because of this, the coordination and collaboration among these teams is very fluid. Further, the coordination and collaboration of these teams seems very unique in comparison to other operational teams, such as military or medical domains.

Teams we have observed in past research show strong task interdependence; what happens in one team member's area of responsibility or if they complete their task greatly impacts other members' abilities to complete theirs. Consider, for example, a surgical team. These teams have clearly defined roles: surgical technologists, surgeons, anesthesiologists, and circulating nurses. Each role has a distinct set of functions. In their environment, the achievement of individual and team goals is closely linked. The surgeon cannot begin his task until the surgical technologist has prepared the room and surgical equipment. Likewise, the RCMP teams cannot enter the building until the Breacher has rammed the door. However, this is the point where collaboration and coordination stops being strictly defined.

Through past research, we define collaboration as the coordinated tasks, goals, or processes carried out by a team of individuals to create a product or shared understanding that none could have come to on his or her own. We define coordination as the joint activities carried out by a team of individuals to outline the tasks and procedures necessary to achieve a desired product or understanding, though they are not dependent on one another to complete their task (O'Dea, Malek, Harris-Thompson, Dominguez, & Rougier, 2005). The RCMP ERTs move back and forth between these states of collaboration and coordination during the course of the house-clearing operation. This shift across the five house-clearing mission phases is illustrated in Figures 7-9.

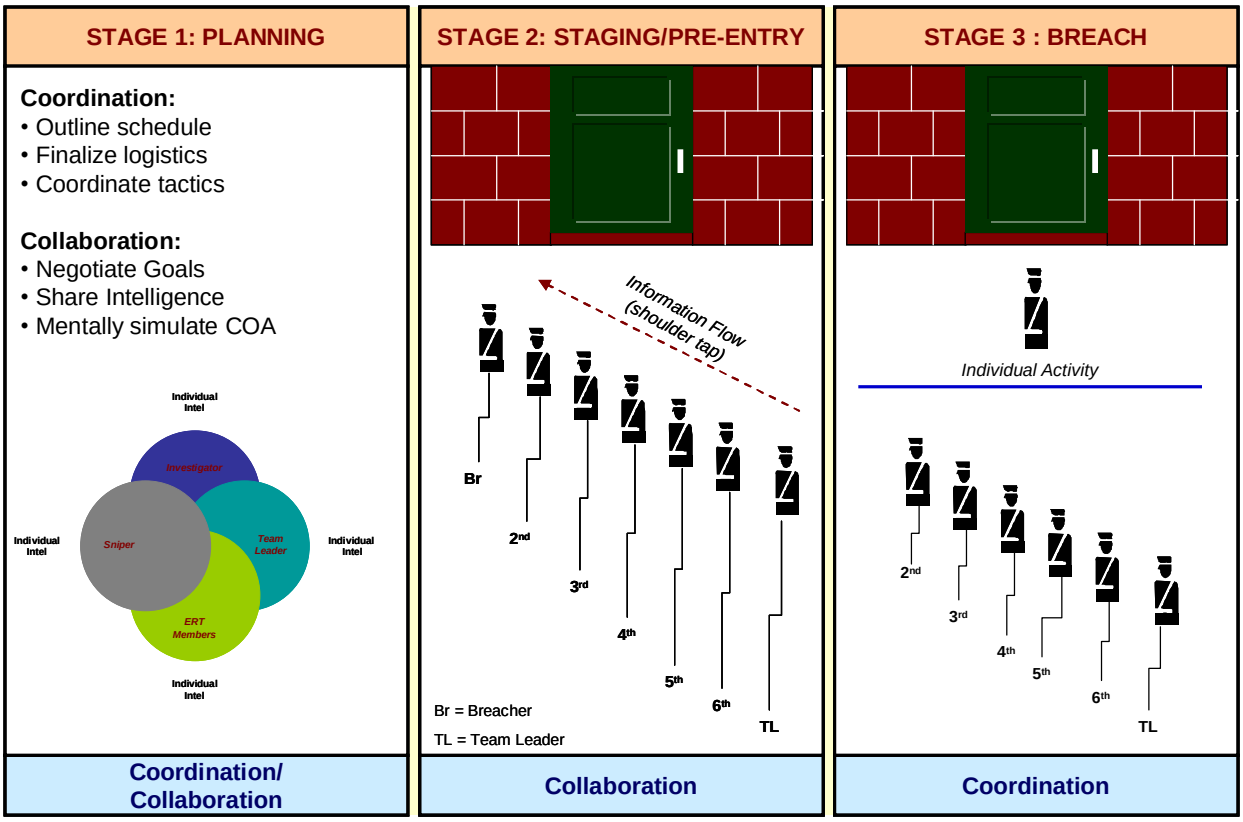
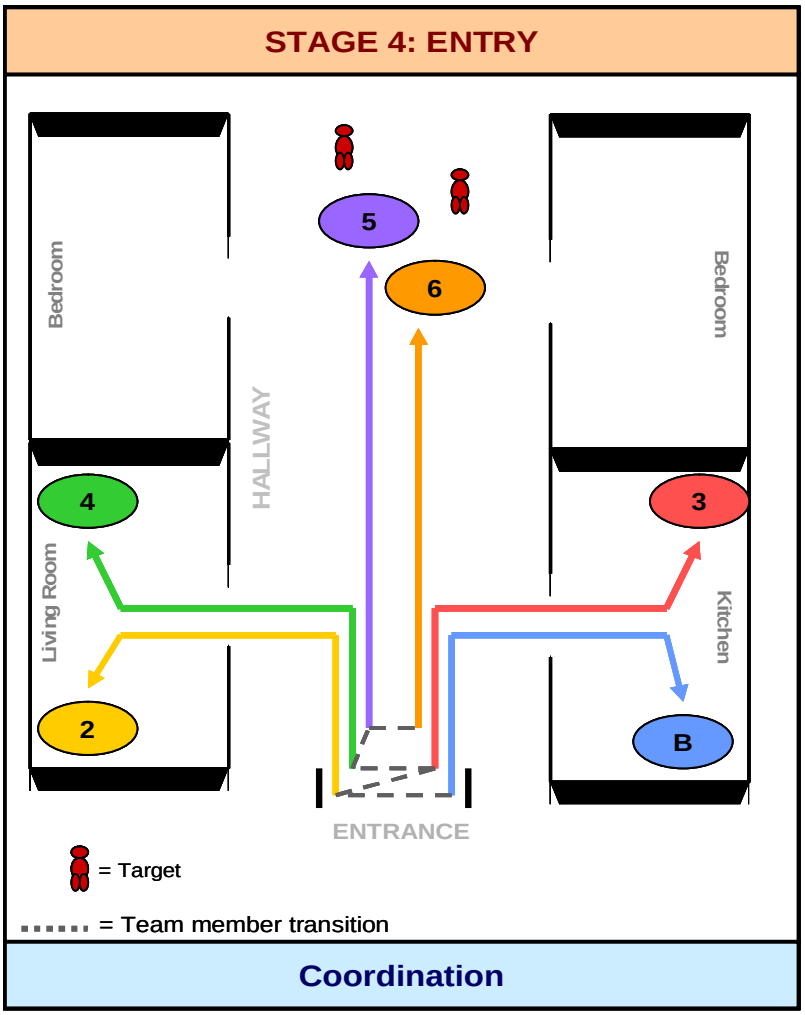


Figure 7. Coordination and collaboration in Stages 1-3 of house clearing.

Pre-entry includes planning, staging, and breach. Stage one is Planning. This has been classified as a mix of coordination and collaboration. Coordinative processes include scheduling, finalizing logistics, and coordinating tactics. These are classified as coordination because they are steps to outlining the process by which the mission will be executed. Individual team members also take steps to collect intelligence. As shown in the earlier list of expert strategies, the steps may include taking pictures of the location or studying the architecture of buildings in the area. This stage becomes collaborative when all members of the planning team (e.g., ERT members, Team Leader, snipers, and the Investigator) share their intelligence to create a shared picture of the environment and threat.

The second stage is Staging (or Pre-entry), which involves collaboration. The staging process (forming outside the entry point) may appear to be basic coordination. However, what makes this stage collaborative is the information sharing that happens pre-entry. From back to front, each team member taps the shoulder of the person in front of him to indicate his preparedness. When the man in the fourth position taps the person in front of him, he is indicating not only his preparedness, but that of each person behind him. Individual team members could not achieve this situation awareness alone.

The third stage, Breach, involves coordination. This stage involves the Breacher knocking down the door (or other barrier to entry) in order for the team to enter. This is coordination because it is an individual task that does not involve other team members.



Stage four, Entry, is a coordinative process (Figure 8). Team members are focused on reaching their individual objective. In this scenario, the Breacher is the first to enter the door. He goes to the right and assumes the right corner of the kitchen. The second person to enter goes in the opposite direction to his objective in the left corner of the living room. Each team member enters in similar fashion, each keying of the person in front of him (this formation is represented by a dotted line in the graphic). Team members five and six enter and proceed down the hall to clear the first bedroom. However, as shown in the graphic, two targets are located at the end of the hallway. This triggers collaboration in the next stage.

Figure 8. Coordination in Stage 4 of house-clearing.

The final stage is Clearing (Figure 9). In the course of clearing the house, teams shift between collaboration and coordination. Stage 5-A shows the collaborative aspect. As shown in Stage 4, Entry (Figure 8), team members five and six engaged two targets at the end of the hallway upon entry. As shown in Figure 9, team member two, in the process of clearing his corner of the living room, also engaged a target. All three team members verbalize something that triggers collaboration among the team. This could be any of the verbal indicators represented in the Team Assessment Cue category of the CCI; including “Police, don’t move” or a call for backup. Because the Breacher and team member three have cleared their individual areas, they are available to provide support. Two key things happen at this point:

1. The Breacher moves across the hall to provide support to number two. He may find upon arrival that number two has the “badger” secured or that number four is positioned to provide backup. The Breacher will make the decision to stay in the room or go to another area, based on his assessment of his teammates’ situational dominance.

2. Number three has moved from his cleared area in the kitchen to the bedroom. Because members five and six indicated (verbally) that they'd engaged "badgers", number three knew that they could not clear their assigned areas. Thus, he filled the gap to move into the un-cleared room. From his visual angle during movement, he could assess his teammates' dominance.

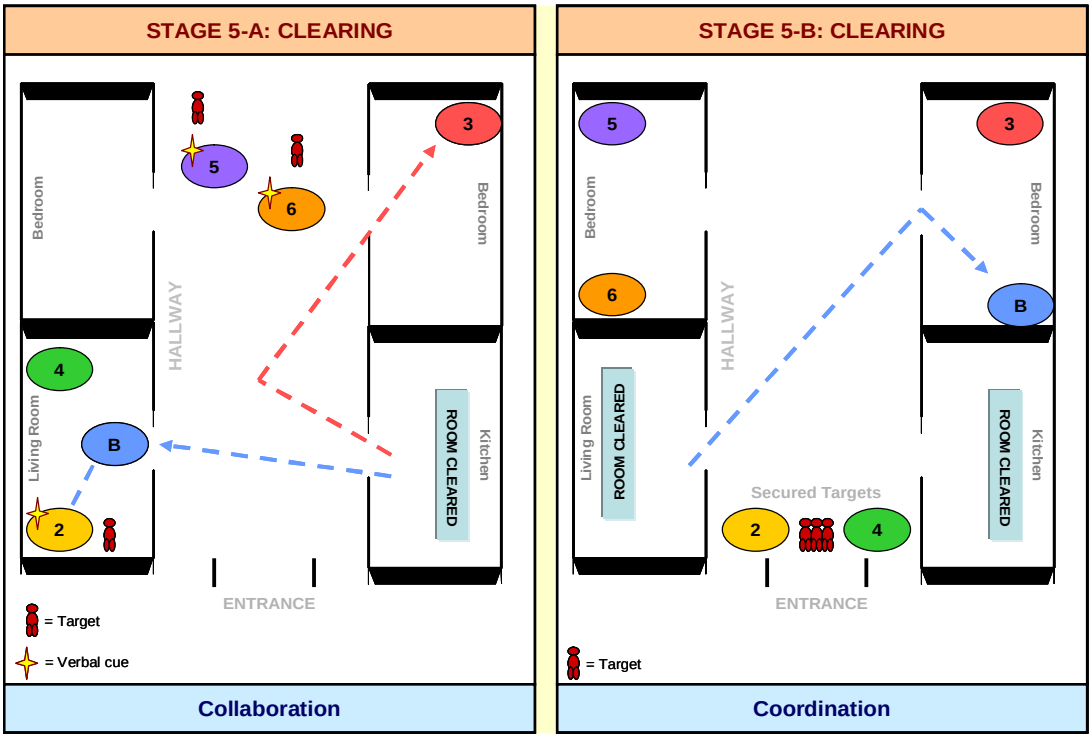


Figure 9. Coordination and collaboration in Stage 5 of house clearing.

Stage 5-B shows the shift back to coordination. Once the living room is cleared, the Breacher moves to cover the right corner of the bedroom on the right. Five and six move to clear the second bedroom, while two and four cover the secure targets. This is coordination because, at this point, the team members have gone back to a focus on individual areas of responsibility.

This example was not developed from a real-world critical incident. Rather, it serves as an illustrative example of coordination and collaboration shifts during house-clearing missions. What cannot be shown in an inanimate graphic is the effortless and automatic way in which these alternations occur. While the critical cues provide some insight into how the experts know when they may need to provide support to their team members, it was difficult for them to deconstruct this team dynamic during interviews. If they are moving into the house, typically the first person in is supposed to go right, the second left, and so forth. But, if the first responder enters that house and finds that the layout is different than expected, he will automatically change his action and the team will automatically fall in. There is no replanning, no in-the-moment discussion, or hand gestures to indicate a need to change the plan. The team just shifts its positioning. This type of performance can be difficult to decompose.

Because these teams train together and have worked cohesively for a number of operations, articulating how they know when to make these shifts is difficult for them. This automaticity is also greatly influenced by the fluidity of the team roles. While the members of the RCMP ERT have performed in some roles more often than others (such as Breacher), cross-training has provided team members the opportunity to shift between roles when necessary. In one example, an SME described his role as the Breacher. The original setup defined him as the Breacher and the first one in the room. However, after he breached the door, because he had nowhere to immediately throw the ram, he had to step back and let the others enter, making the original second person the first person in and the Breacher had to get in when there was a gap in the formation. This cross-training has further enhanced the RCMP "team mind".

This necessary cross-training can be achieved through team-based training scenarios. First, by having the team perform together in a scenario, they will begin to build an understanding of the various roles and functions of the team as well as their team member's abilities. Further, training scenarios can be used flexibly to enhance this cross-functional understanding. For example, by having the participants shift roles in the scenario, they can begin to build skill in filling a team member's role. This can also help them in interpreting cues differently; as cues will be relevant for different reasons based on the team member's role and goals in the mission.

Each of these findings reflects a key performance and training area for house-clearing tasks and missions. Following is a discussion of how this research and its findings feed into the development of decision-centered training requirements and scenarios.

VI. CTA IMPLICATIONS FOR TRAINING

As shown through this research, house-clearing missions include a wide range of decision requirements which specify the cognitive demands facing the decision makers. One potential reason for the virtual exclusion of decision-making training within instructional programs for house clearing is that it is so difficult to identify the decisions and cognitive strategies used by skilled forces. It is generally only the experts in a field who have a bank of knowledge regarding how to effectively deal with these critical decisions. And, like experts in most fields, they often cannot articulate the tacit knowledge surrounding their decision making without the use of methods designed to elicit such information.

The danger here is that soldiers and police officers, no matter how well-trained and prepared to carry out difficult actions, cannot be protected from the consequences of their poor decisions. House-clearing missions place officers in highly demanding situations where they have to make a series of split-second decisions using a combination of SOP and RPD. Thus, relatively inexperienced CF and ERT members are going to be facing high risks and demanding situations with very little preparation for handling the decision requirements of house-clearing missions. Creating more effective cognitive training can help ameliorate this situation.

In this section, we review the research findings that support our approach to creating effective cognitive-based training scenarios. The primary foundation for our work is the research

on the nature of expertise—what expert cognitive performance looks like and how it is developed. This is followed by a description of how to leverage critical cognitive cues (and other cognitive elements of performance) to create effective cognitive training using a scenario-based training approach.

The Role of Expertise in Training Cognitive Skills

Surrogate experiences are a key part of effective training for high-level cognitive performance, and scenario-based training is one way to create those experiences. Subject-matter experts can construct scenarios from their doctrinal knowledge, their experiences, and the experiences of their colleagues. But lack of clear guidelines and little understanding of high-level cognition impede the routine and effective use of scenario-based training for house-clearing missions. However, cognitively effective training for house clearing can be created by providing surrogate experiences that promote the development of expertise.

To develop expertise in any domain one must learn large amounts of technical information, and expert performance requires the ability to link facts and causal relationships with the cues, expectancies, goals, and typical actions relevant in that domain. However, factual knowledge that is not acquired through experience—real or surrogate—is sometimes not accessible during later performance, and, therefore, may not contribute to advanced learning or performance. Learning of de-contextualized facts leads to "inert knowledge" or "knowledge that can usually be recalled when people are explicitly asked to do so but is not used spontaneously in problem solving even though it is relevant" (Cognition and Technology Group, 1990). When people learn new information in the context of meaningful activities, rather than as an abstract set of facts, the knowledge is indexed, expanding the learner's mental models. Such knowledge is automatically accessed during performance as a tool to make a decision or solve a problem. Brown, Collins, and Duguid (1989) argued that in order for knowledge not to become inert, learning must be embedded in the social and physical context within which it is to be used. As soon as possible in the process of developing experts for a domain, technical knowledge must be integrated into realistic contexts such as scenario-based learning.

Bransford, Sherwood, Hasselbring, Kinzer, and Williams (1990) described the alternative to memorizing and recalling facts and figures out of context as "conditionalizing" knowledge (i.e., acquiring knowledge "in the form of condition-action pairs mediated by appropriate goal-oriented hierarchies rather than as isolated facts" [p. 120]). When a learner perceives new information as trite or old, as is often the case when information is given out of a specific context and without a performance goal, the knowledge will not necessarily be remembered and cannot be applied appropriately. We have seen this many times in the area of military expertise. In our work to engage military students in advanced learning, we will often describe mental models associated with tactical decision making. Students will assert that they already know this information (such as the need to generate a story of what the enemy is doing and will do) as if the mental models are somewhat trite. However, knowing about the mental models and applying them to realistic problems are two very different kinds of knowledge, as we have discovered in scenario-based training sessions. The development of contextualized mental models supports the transition from the novice who uses hastily formed, concrete, and superficial problem

representations, to the expert who uses deep structures to represent what they are seeing (Larkin, 1981).

The opportunity exists to capitalize on the house-clearing expertise that exists within CFs and RCMP ERTs to identify the critical cognitive aspects of decision making and the (contextualized) mental models that can enhance current military training programs. The ERT members we interviewed have extensive experience in actual house-clearing missions, learned lessons, and have developed mental models that cannot be found in training manuals. By using a combination of CTA methods to elicit these lessons and mental models, we identified key decision requirements of house-clearing missions (the aspects of expertise). These decision requirements can now be converted into training requirements to improve simulated training for house clearing. This training cannot make team members experts overnight, or even within a few months, but it can dramatically accelerate their learning and better prepare them for the judgments and decisions they will be required to make when they are given house-clearing assignments.

Developing Cognitively Authentic Training

Understanding the elements of perception, recognition, and decision making inherent in cognitively challenging tasks is the basis for creating cognitively authentic training experiences (Harris-Thompson, Mills, Ross, Peluso, Baxter, McCloskey, & Palmer, 2004). As discussed earlier, when developing training, the goal should not be to present a simulated environment that mimics the physical elements of the real world. Rather, training simulations should provide surrogate cognitive experiences that challenge decision-making skills for the trainee. This will prepare Canadian Forces for more effective performance and decision making during their real-world tasks and missions.

Physical fidelity is important for some learning objectives, such as the assessment of visual cues in the environment. However, it is not a substantial requirement for training the types of skills identified in this effort as critical to completing house-clearing tasks (such as the recognition of environmental and team cues). Incorporating more cognitively authentic cues will allow training developers to more successfully provide authentic decision and judgment dilemmas with appropriate context.

In formulating a program to train house-clearing skills, a training developer can go down many different paths, and supplement the entire course with factual information relevant in these settings. However, consider what happens if we incorporate decision requirements such as those gleaned from house-clearing experts and represented in DRTs. A host of materials from historical incidents becomes relevant for illustrating issues such as how teams worked together or how routes were determined and where mistakes were made. Elements can be taught in the context of the cues and factors that are considered when assessing a situation. Scenarios can be developed that pose dilemmas around those decision requirements, create certain types of ambiguity, and require the trainee to judge which types of information are necessary and easy to obtain within time constraints. Feedback sessions can be directed at the strategies used to assess a situation, along with the strategies for carrying out the responsibilities. An understanding of decision requirements is important for identifying and framing these types of interventions.

Research Implications for Training

The CTA described in previous sections of this report has identified some of the cognitive challenges of house-clearing operations. Having specified the cognitive challenges of the task in the form of decision requirements, we can now determine requirements for decision-centered training scenarios.

The decision requirements identified in this research highlight the following training points related to house-clearing operations:

- decisions, judgments, and assessments that are crucial to mission accomplishment
- aspects of the decisions, judgments, and assessments that are difficult for inexperienced team members
- the critical pieces of information (cues and factors) that team members should take into account when making decisions and judgments
- the strategies and rules that house-clearing experts have developed to improve their decision making and execution of urban operations

Each of these items represents knowledge that resides with experts, but can be transferred to less-experienced personnel through well-designed training. Therefore, the decision requirements are, in fact, training requirements. If an instructor wants to teach how to clear a house, the student must learn how to approach the house, enter the house, clear the house, and handle any suspects encountered. While conducting each of these steps, the student must also learn how to consider the situation assessment cues (e.g., time of day), environmental assessment cues (e.g., size and location of the house), threat assessment cues (e.g., suspect's body language), and team assessment cues (e.g., tone and volume of voice). To teach these cognitive skills, an instructor can refer to the training points shown in the DRTs. These points include the cues that the student will need to notice and interpret, the factors that he must take into account when making decisions, and the strategies and rules-of-thumb that have been developed by house-clearing experts. One way to capitalize on these training requirements is through the use of scenario-based training, such as the Dismounted Soldier Simulators currently in development by DRDC scientists.

Developing Scenario-Based Training

Training the cognitive aspects of decision making related to house-clearing tasks can be best accomplished by employing a scenario-based approach which can boost the expertise of students in decision making. Scenario-based training will present trainees with the same decisions, judgments, and assessments they will face in the operational environment. Further, this training approach can also address the issue of perishable skills by providing opportunities to participate more often in simulated house-clearing missions with less expense and no threat to safety.

Scenario-based training exercises are simulations of incidents that might occur in operational environments. They can have low or high physical fidelity depending on the importance of precise visual cues to the decision task. The scenarios present dilemmas with high levels of uncertainty. Each participant has a limited amount of time to consider how he would react, which adds time pressure to the exercise. Scenario-based training that is built from CTA data provides experiential training and allows practice in rapid decision making. It can provide several benefits:

- improve one's ability to make decisions quickly and effectively; and reflect upon the reasoning behind the decisions
- begin to make better sense of new situations, see patterns, and spot opportunities and options that were not seen before
- become more comfortable with a variety of different situations
- develop more advanced and ambitious tactics
- become more familiar with the affordances of different weapons, employment techniques, and other technical details

Perhaps the most important benefit of scenario-based training is that it provides participants with practice in operational decision making in a safe, cost-effective manner. While scenario-based training can never fully simulate the stresses of real operational conflict, when developed properly, it can expose the participants to a wide range of challenging, and authentic, decisions.

It is important to note that the development of decision-based training is not as simple as distributing cognitive information randomly throughout a scenario. Just as it is necessary to use methods designed to elicit aspects of expertise, it is also important to know how to embed that information to effectively transfer knowledge to novices. To maintain plausibility, information must be staggered throughout the scenario in the same context that it would be received in the real world.

While a scenario can be developed by simply making up a situation and environment, and then requiring some action, a more focused approach to development can result in a higher quality exercise. By starting the development process focused on specific challenging decisions that an envisioned participant can be expected to face, a scenario can be created that forces the participant to deal with those decisions. In this way, scenario-based training can be tailored to specific training demands, known difficult cognitive challenges, or even particular events in upcoming exercises.

Translating SME Incidents into Scenario-Based Training

One approach to developing authentic decision-based training scenarios is to build on real-world examples provided by SMEs. For example, the annotated incident provided in Figure 6 provides a good basis for a scenario. By highlighting cognitive information in an elicited example, training developers can see not only what information and cues are most critical to

decision making, but also the order and or method (visual, auditory, tangible) through which these cues would be received. By dissecting and building on the incident shown in Figure 6 (or presenting the incident to trainees as is), trainees can be challenged on critical performance elements such as environmental assessment (would a trainee recognize the implications of a chimney that goes down to the ground) and decision making (would a trainee spend time clearing rooms inside that had been cleared from the outside or, as the expert did, redirect his attention to unknown areas).

Using this type of incident, trainees can be required to develop their own COA based on their perception and interpretation of the cues presented in the scenario. It also provides a valuable opportunity for trainers to evaluate trainees' performance based on how they managed the situation compared to the expert.

Translating DRTs into Scenario-Based Training

Another approach to scenario development is through leveraging DRTs. Scenario-based training exercises can be tailored to specific decision areas in the scenario design process. Using the DRTs containing judgments and decisions that make house-clearing operations difficult, scenarios can be developed to significantly ramp up the trainees' learning curve by giving them practice making the assessments, judgments, and decisions they will face in the operational environment.

Typically, we construct training scenarios in terms of General and Specific Situations. The General Situation, presented first, gives trainees background information about the situation that should be important to their later decision making. In the Specific Situation, trainees are presented with environmental indicators that should directly impact their decision making in the moment. In other words, the General Situation incorporates factors, while the Specific Situation incorporates cues. Other information from the DRT (including areas where less experienced operators could make mistakes) is spread throughout the scenario. Table 5 provides guidance on how DRT information should be integrated throughout training scenarios.

Table 5

Integrating DRT Information into Training Scenarios

GENERAL SITUATION		
DRT Category	**Scenario Integration**	**Example**
Why Difficult	§ Develop the *General Situation* with conditions that add difficulty or challenges in order to enhance the dilemma that will be presented later in the scenario. § For an advanced scenario, incorporate several Why Difficults. For a basic-level scenario, use fewer.	§ There is a lot of loud music playing. § The suspect has three hostages. § Members of the media are in the area capturing the event on film.
Factors	§ Incorporate as descriptors of the mission (e.g., recent events or rules of engagement). § Factors should ground the trainee in the operational setting so he or she will understand what actions are appropriate. § Factors should prompt the trainee to mentally set expectations about the enemy, populace, and friendly forces.	§ This is an eight-year old residential building. § This is a two-story building. § The suspect typically wakes up at 5:45 am.
SPECIFIC SITUATION		
DRT Category	**Scenario Integration**	**Example**
Why Difficult	§ Introduce a Why Difficult as a change in the situation or unexpected event that challenges the trainee. § Why Difficult points can serve as the basis, or a component, of the dilemma faced by the trainee.	§ The door is difficult to breach. § Upon entry, you find the room layout is different. § The floor is covered in soda cans and beer bottles.
Cues	§ Weave cues throughout the Specific Situation to create a picture of what the trainee would sense in the environment if he or she were actually performing in it. § Cues can be definitive or ambiguous depending on what would be realistic and how much uncertainty is desired for the training. § Visual representations should be used to provide cues that are better represented graphically (e.g., room layout).	§ You hear your team mate down the hall yell, “Police, don’t move!” § Suddenly, you hear a door slam shut in the back of the house. § Your Team Leader calls over the radio that a crowd of onlookers is beginning to develop outside.

Other information captured in the DRT, expert strategies and novice errors can be used to support facilitation of the scenario. A facilitator can highlight potential errors trainees may make

in the presented situation (e.g., not focusing on key threat areas) and discuss the consequences of those errors with trainees. Using the expert strategies column, the facilitator can develop methods to help trainees learn and understand the value of these strategies (e.g., have suspects keep their hands high so they will have to make large movements to be a threat). The facilitator can then guide discussions on when these strategies are and are not appropriate.

As described in this section, the information requirements identified through the use of CTA provide richness to training that cannot be achieved through the sole emulation of physical environmental features. Though these physical features can provide value to training in this domain (seeing levels of a house before entry is important to decision making), to take full advantage of emergent virtual training technologies, developers should also take steps to include cue-based information that contributes to judgment, assessment, and decision making in these tasks. This research effort has taken the first step in isolating and classifying these types of critical cues.

VII. CONCLUSIONS

Current training does not adequately address the unique decision making considerations for house-clearing teams, primarily because the need for such training has only become critical in the past decade. For this reason, one side objective of this effort was to determine the feasibility of using CTA to identify the decision-based training requirements for these missions and tasks. During this effort we were able to:

- confirm that expertise does exist within the house-clearing task
- demonstrate that CTA is effective for capturing the decision requirements of house clearing
- elicit critical decisions, cues, factors, difficulties, rules, strategies, and other relevant knowledge gained from experience in house clearings
- demonstrate that the results of CTA can be translated into training requirements

This research effort has shown that recognition-primed decision making is dominant in the house-clearing environment. Because of this, training that focuses solely on assessment of the physical environment will not adequately prepare operators for performance in these missions. It must also include task requirements that lead trainees to develop the decision and assessment skills experts have communicated as mission critical.

Trainers seeking to develop decision-centered training scenarios for use in the Dismounted Soldier Simulators can leverage the output of this research. To build effective surrogate experiences that train the cognitive skills required for house clearing, training developers should combine:

- a variety of tasks from the Task Diagrams that stress individual, coordinative, and collaborative action on the part of the trainees
- a relevant mix of cues from the CCI to allow trainees to practice rapid recognition and interpretation of threat, environmental, situational, and team assessment cues
- the tasks and cues in a manner that will challenge trainees not to succumb to tunnel vision or tunnel hearing
- elements from the Factors, Strategies, and Why Difficult columns from the DRTs to enhance the realism and modulate the difficulty of the training scenarios

The CTA research conducted in this effort will allow for more meaningful and cognitively-valid scenarios in the DSS and GIS. Performance evaluation through these simulators will yield further data that can be fed into other tools that address a variety of human system integration challenges, such as the Integrated Performance Modeling Environment (IPME).

Recommendations for Future Research

Continued Data Collection through Interviews and Observations

Cognitive Task Analysis methods (such as those used for this data collection) provide details around the judgments that surround problem solving and decision making in a particular task or domain. For most tasks and domains, the use of interviews with SMEs is sufficient for obtaining a rich representation of the cognitive aspects of the task. However, there are some tasks and domains that are so dynamic that interviews must be supplemented with observations. During interviews with the ERT SMEs, several noted that if we were watching a video of them doing the task, it would be easier for them to convey what they were noticing at different times and how it influenced their actions. It was difficult for them to remember and unpack all of that information during the interviews. For this reason this research should be continued to explore the task through observations.

Optimal observations will likely be provided through data collection at a U.S. Marine MOUT (Military Operations in Urban Terrain) training center. The Marine Corps has focused significant attention on urban operations. The Marine Corps has several urban training facilities, including the Urban Complex located at Camp LeJeune, the Basic Complex located at Quantico, and the Mission Rehearsal Exercises conducted at 29 Palms and Camp Pendleton. Attending one of these exercises will allow us to observe forces in the environment, document changes in the environment, and interview SMEs following the exercise on their situation assessment and decisions. Conducting interviews around a recently completed exercise or training event has proven very useful in understanding decisions made in more complex environments.

Data collected with U.S. Marines following exercises will also provide more direct insights into the team performance. Military teams do not typically train and perform as an intact team for the same length of time as the ERTs we interviewed do. This may make it easier for

them to communicate what they observe in their team members' performance and how they react to it. It will also get further at issues of coordination and collaboration as well as mutual trust.

Additional research is needed to better understand how situational assessment is communicated amongst team members and how to use the critical cue inventory to develop cognitively authentic exercises for simulated training environments.

Development of Decision-based Training Scenarios

Though the need for continued data collection exists, what has come from this research effort provides an immediate value to emerging training simulators. The blending of perceptual cues, situational constraints, team challenges, and RPD events will lead to the development of robust, authentic training scenarios.

Klein Associates has shown, through an extensive repertoire of research and development, that training for tasks in contemporary operational environments can be enhanced by using CTA to generate the decision requirements and training content. Below are some examples of cognitively-authentic and effective training that we have developed using the types of methods and processes discussed in this report:

Decision Skills Training (DST)

One scenario-based training approach employed with units of the U.S. Marine Corps is Klein Associates' Decision Skills Training (DST) (G. Klein, McCloskey, Pliske, & Schmitt, 1997). The DST program is highly contextual, oriented around decision requirements identified for a specific task and group of people. The decision requirements guide the development of a series of training scenarios called Tactical Decision Games (TDGs) as well as other training tools that enhance the use of the TDGs.

Improving Performance through Applied Cognitive Training (IMPACT)

This project, conducted for the U.S. Army, capitalized on the considerable MOUT experience that exists among selected soldiers to identify the critical cognitive aspects of MOUT decision making and subsequently enhance Army training in MOUT. To meet this need, a scenario-based program was assembled based on DRTs and a user needs analysis. Two products constitute the training program. The first is a multimedia, train-the-trainer CD-ROM titled IMPACT—IMproving Performance through Applied Cognitive Training (Klein Associates Inc., 2001), which was developed to prepare and support instructors in developing and facilitating Decision Making Games (DMGs). The CD also includes a substantial library of DMG scenarios that have been carefully structured to simulate practice in effective decision making. The second product is a supplementary paper-and-pencil exercise, the Situation Awareness (SA) Appreciation Exercise, which was developed to guide instructors in the specifics of facilitating the understanding of the changing nature of SA during mission execution.

Stability and Support Operations (SASO) Training

In this project for the U.S. Army, we developed scenario-based training in the form of Decision Making Exercises (DMXs) delivered over the Internet to improve the preparedness of soon-to-be deployed soldiers to perform Stability and Support Operations (SASO) in the Balkans (Klinger and Thordsen, 200?). A range of CTA techniques was used to capture the decision requirements specific to the Balkans environment. These decision requirements were used as the training requirements for a series of training scenarios designed to sensitize soldiers to the nature of the critical decisions and judgments they would face, the reasons those decisions are difficult, the typical errors novices make, the subtle cues and other factors that impact the decisions, and the strategies used by experienced decision makers.

Enhancing Situation Awareness (Enhancing SA)

The objective of this effort was to provide an effective training tool for leaders to improve their situation awareness. We accomplished this by supporting the development of a training tool, in the form of a web-enabled simulated decision environment, for leaders to improve their situation awareness and their skills at sizing up a situation (Phillips, Baxter, & Harris, 2003). This tool incorporated critical cues and factors critical to performance in a battlefield environment. Through this tool, we measured the students' improved ability to perceive the critical elements within an ambush situation, combine those elements to develop a coherent understanding of the situation, and take appropriate actions to prevent and or support those future events.

Battle Command Knowledge System (BCKS)

The purpose of the Battle Command Knowledge System is to provide ongoing, near real-time support to the U.S. Army through the creation of a pervasive system of knowledge sharing networks and processes (Baxter, Ross, & Stevens, 2005). The goal of this effort was to understand how to capture and use tacit knowledge currently being created during deployment in Afghanistan and Iraq. If this knowledge is successfully drawn from experiences of those soldiers who are currently deployed and transmitted effectively, BCKS can use the knowledge to support the development of tactical thinking expertise throughout the Army. To meet this goal, we examined the nature of knowledge available to BCKS from the field experiences of deployed leaders, both officers and NCOs. We specifically elicited and analyzed performance challenges and tacit knowledge embedded in critical decisions in the operational environment by conducting 54 CTA interviews. This data will be available through the BCKS to improve the training of tactical thinking for soldiers.

electronic Medium for Authoring and Generating Instructional Experiences (eMAGINE)

The purpose of this project for the U.S. Navy was to help instructors and course designers find a way to share the knowledge of experts with students through scenario-based training (Harris-Thompson et al., 2004). Training developers were looking for efficient ways to capture and incorporate their experiences or the experiences of others into an easy-to-implement training solution. We identified, expanded, and refined the best practices in scenario development and

built a tool that teaches novice training developers and supports expert developers in building cognitively-authentic training scenarios. We also developed a process for scenario-specific knowledge elicitation as a way to help developers more accurately capture the cognitive elements that exist in the natural environment so they can more accurately represent the decision space of the operating environment for their students.

These example applications show the translation of CTA into scenario-based training. What they also show is the value that well-constructed scenarios that incorporate key perceptual challenges can provide to various tasks and domains. Undoubtedly, Dismounted Soldier Simulators that leverage scenarios with this level of cognitive validity will provide improved training to new personnel and give researchers the ability to evaluate performance improvement.

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APPENDIX A

DATA COLLECTION PLANNING MATRIX

		Secure the Perimeter	Approach the Building	Enter the Building	Clear the Building	Maintain & Extend Security	Evacuate the Building
INDIVIDUAL	Sensemaking	▲ X	▲ X	▲ X	▲ X	▲ X	--------------------
	Replanning	---------------	▲	---------------	--------------	--------------	-------------------
	Problem Detection	▲ X	▲ X	▲ X	▲ X	▲	▲
	Coordination	---------------	--------------	---------------	-------------	---------------	--------------------
	Situation Awareness	▲ X	▲ X	▲ X	▲ X	▲ X	▲ X
TEAM	Sensemaking	▲ X	▲ X	▲ X	▲ X	▲ X	▲ X
	Replanning	▲	▲ X	▲ X	▲ X	▲	▲
	Problem Detection	▲ X	▲ X	▲ X	▲ X	▲ X	▲ X
	Coordination	▲ X	▲ X	▲ X	▲ X	▲ X	▲ X
	Situation Awareness	▲ X	▲ X	▲ X	▲ X	▲ X	▲ X

X = exists/important in this context/task ▲ = important for project/customer

APPENDIX B

DATA COLLECTION GUIDE

DATA COLLECTION GUIDE

Data Collection Objectives

1. Achieve an understanding of the challenges inherent to different types of house-clearing missions
2. Identify critical cues and information used by individuals and teams to develop and maintain situation awareness (SA) during house-clearing missions
3. Understand how information is shared between team members to support shared SA
4. Explore expert-novice differences in cue identification and application (how they use cues to support their SA)

Background

- SME demographics (current job title & role, number of years in current job, examples of house-clearing experience, etc.)

I. INDIVIDUAL INTERVIEWS

Method(s): Task Diagram, Knowledge Audit
Outcome(s): The combination of Task Diagram and Knowledge Audit will provide:

- An understanding of the cognitively challenging tasks inherent to house-clearing missions
- The types of cues and information used to assess situations during house-clearing missions
- How these missions can be challenging for less experienced soldiers

Initial Probe

- Are there different types of house-clearing missions? How many? Can you briefly describe the differences between them?
- Which one(s) is most common?

Begin by task diagramming the most *common* (the one they're most experienced with) house-clearing mission.

A. Task Diagram
   a. **Probe:** Think about when you've participated in this type of house-clearing mission. Can you break this down into three to six steps? [Document these tasks]
   b. **Probe:** Of these steps, which would you say are the most cognitively challenging; requiring the most judgment, assessments, and problem solving?

B. Knowledge Audit
   a. Write table with the following columns - Task step, cues, strategies, why difficult
   b. **Probe:** In this situation (with this task step) how do you know what to do? What cues are you relying on?
   c. **Probe:** How do you use these cues do develop an action strategy?
   d. **Probe:** In what ways would this part of the house-clearing task be difficult for a less experienced person?
   e. **Additional Knowledge Audit Probes:**

i. What are the major elements you have to know and keep track of during house-clearing tasks/missions (Big Picture)?
ii. Can you describe a time when you spotted a deviation from the norm or something went against what you expected? What cues or information caused you to question your expectation (Anomalies)?
iii. Have you had experiences where part of a situation "popped" out at you and you noticed things going on that others on your team didn't notice? What is an example (Noticing)?

We will explore what comes out of the Knowledge Audit with CDM-like questioning.

* If time permits, we'll explore other types of missions the SME may mention.

QUESTIONS FROM DRDC TEAM

- What are the differences between RCMP and Army when it comes to mission execution?
- How are these guys trained?
  - What kind of scenarios are they using?
  - Do they use any type of virtual simulator in training?
- How are the soldiers trained for unexpected events? Is there any training on fast role-switching under the "3-block warfare" concept?
- What are typical cases? Give some typical and non-typical examples, or workable and non-workable examples?
- How does physical/cognitive workload affect soldiers' decision making?
- How do emotions and personality affect soldiers' decision making?

II. TEAM INTERVIEWS

Background

- Identify the roles each SME holds on the team (how should they be assigned for the scenario?)

Method(s): Simulation Interview
Outcome(s): The simulation interview will provide:

- Generalizeable cues, but within a structured context
- When run with experienced and less-experienced teams we'll see expert-novice differences in situation assessment
- By assigning roles, we'll understand how different team members use cues to assess the environment and how they share that information

A. Introduce the simulation

B. Divide the team into two groups of two. Each 2-person team will read the scenario with the following guidance: Please read the scenario and generate your course of action. At the end of the time, we will debrief your course of action and ask questions around the information and cues you were paying attention to, your understanding of the situation, and what is difficult about this type of mission.

C. We'll ask the first group to debrief their COA and document their information on the simulation interview table (Five columns: Events, Actions, Situation Assessment, Critical Cues, Potential Errors)
   a. **Probe:** What actions, if any, would you take at this point in time? (Actions Column)
   b. **Probe:** What do you think is going on here? What is your assessment of the situation at this point in time? (Situation Assessment Column)
   c. **Probe:** What pieces of information led you to this situation assessment and these actions (Critical Cues column)
   d. **Probe:** What errors might an inexperienced person make in this situation? (Potential Errors Column)

D. We'll discuss the differences and similarities in the group's courses of action; particularly around the importance of the identified cues and/or why one group identified cues that the other did not.

APPENDIX C

SURPRISED BY AN UNEXPECTED ENEMY

Title	Difficulty Level
Surprised by an Unexpectant Enemy	**Basic**

Executive Summary

This game is an all out war situation in which U.N. forces have halted the advance of invading forces and are now pushing the remaining enemy battalion back toward their national boundary. The scenario takes place in a deserted village made up of one-story buildings. The platoon is in a large warehouse, checking supplies and communicating with the rest of the company, when 8 enemy soldiers are spotted milling around outside a building down the street. Two of them then cross the street and enter another building. The platoon's mission is to destroy or capture all enemy forces.

Scenario Text

Task Organization: Bravo Company, 1st Battalion, 5th Infantry (Light)

1st Platoon
2nd Platoon
3rd Platoon

You are the leader of 2nd Platoon, Bravo Company.

I. Situation

A neighboring country, Candia, has invaded the small, allied Middle-Eastern nation of Slavia. The Candians have ruthlessly pushed south, through countless small villages in an effort to reach the capital city of Taznia. Task Force Hammer, 2nd Brigade, 12 Infantry Division (Light) has been deployed as part of a multi-nation, U.N. fighting force to repel the invaders. The U.N. force has succeeded in halting the advance of the invading forces, and is currently pushing the remaining enemy battalion back toward their national boundary, and clearing all scattered enemy forces they encounter in the small villages they approach. Any non-UN personnel that are encountered are assumed to be enemy forces.

A. Enemy Forces (Intelligence Reports)

In the past week, the enemy forces have been mainly reactive and attacking only sporadically. They have been operating in small groups of 4-8 soldiers, and have been hesitant to launch any significant offensive efforts. The forces have been passive, and are typically armed with small arms, mortars, and anti-tank weapons.

B. Friendly Forces

1st Battalion, 5th Infantry clears AO Fist in order to allow UN forces to reestablish the Slavia national boundary.

II. Mission

Bravo Company clears Sector Kilo of enemy forces to protect the Battalion rear command post from enemy attack.

III. Execution

A. Commander's Intent

I want all villages thoroughly searched and cleared of all enemy elements. We can not allow enemy forces to escape the villages and conduct hit and run operations against the battalions line of communications. Destroy or capture all enemy forces.

B. Concept of the Operation

1st Platoon, main effort, clears the village of Humbugi to protect the battalion rear command post. 2nd Platoon clears the village of Timbaka of enemy forces to prevent enemy attacks along Route Yankee, the battalion main supply route. 3rd Platoon provides escort for LOGPAC convoys forward of the Gardina River to allow resupply of Alpha Company, the Battalion main effort. Priority of fires is to 1st Platoon.

IV. Rules of Engagement

Nothing in these ROE limits your right to take appropriate action to defend yourself and your unit.

a. In this high-intensity conflict, you have the right to use force to take appropriate action to defend yourself and your unit, and to achieve your mission.

b. Hostile fire may be returned effectively and promptly to stop a hostile act.

c. U.N. forces can use any force deemed necessary under the circumstances and proportional to the threat.

d. Detention of civilians is authorized for security reasons, self-defense, or to support achievement of the mission.

V. Scenario

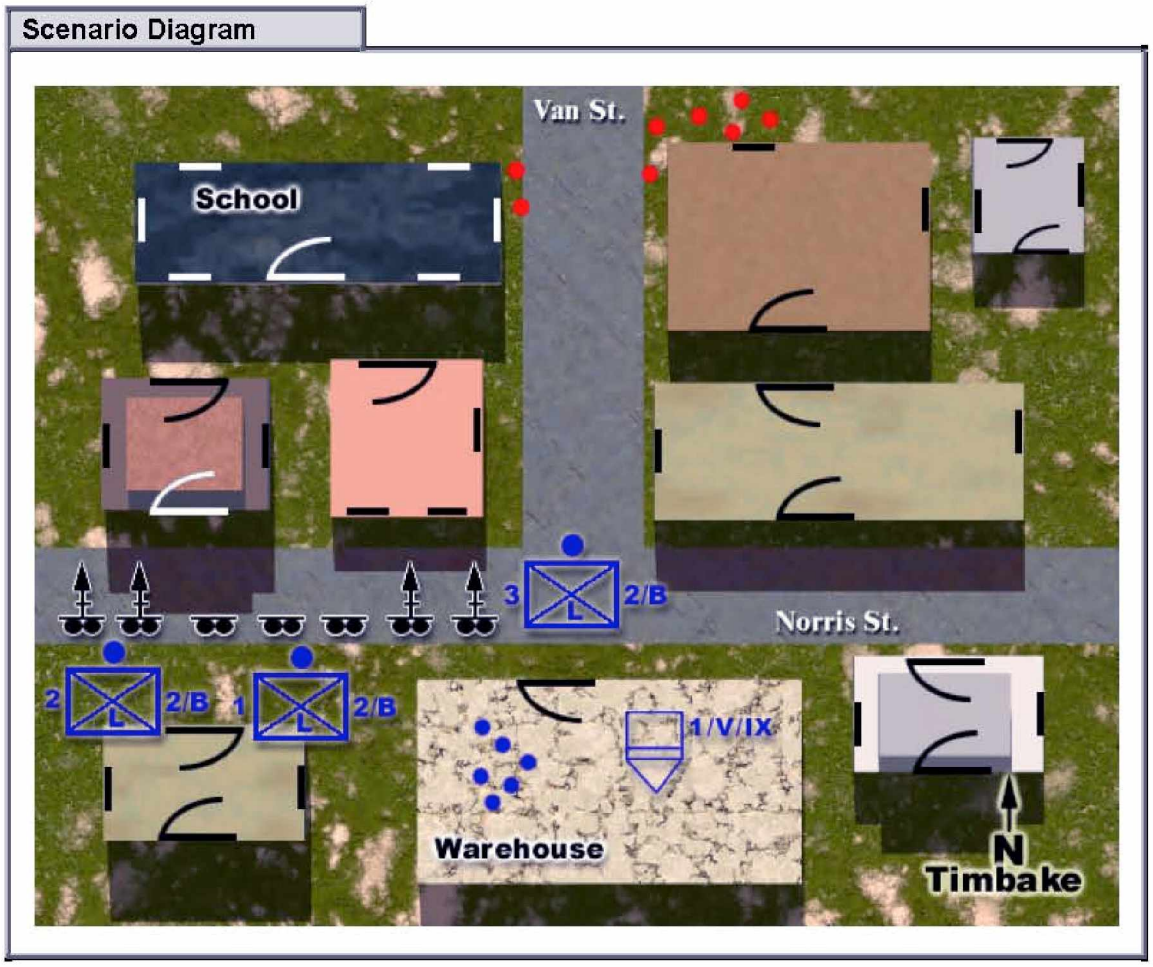
You are in HMMWVs mounted with M240 machine guns and have stopped momentarily in the deserted town of Timbaka, which consists mostly of one-story buildings. You are currently in a large, one-room warehouse, checking supplies and communicating with rest of company. The company commander is 2 km north, and had earlier told you that an intel update from the S-2 suggests that there may be a small (no more than squad-sized) enemy force in Timbaka. He has directed you to ensure the town is clear, and then catch up with the rest of the company. The time is 2200, and the overcast skies create a darkness that prevents the naked eye from seeing more than 100 feet. Fortunately, your unit is equipped with NVGs.

You are inside the warehouse conferring with two of your squad leaders when your platoon sergeant, who is with the security element outside, calls in: "LT, one of my men just observed about eight enemy soldiers milling about in a building down the street. It's pretty clear that they don't know we're here, or else there would be some commotion. The other buildings appear to be deserted, although there's really no way to tell for sure without checking them out. Wait a minute… A couple of them just popped out of the building and went across the street to the school. They were carrying grenades and AK-47s.

What do you want to do?"

VI. Requirement

In a time limit of 2 minutes, develop your orders as you would issue them to your squad leaders, along with your rationale and any other communications you would make.


Scenario Diagram
Van St.
School
Norris St.
3
2/B
2
2/B
1
2/B
1/V/IX
Warehouse
N
Timbake

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(U)

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(U) Increased urbanization has created a rise in Military Operations in Urban Terrain (MOUT), in which units find themselves operating in cities rather than on traditional, uninhabited battlefields. MOUT presents a uniquely challenging environment to soldiers and leaders. Beyond challenging basic tactical skills, these environments call on personnel to make faster, more advanced decisions based on a multitude of environmental information. It is important for personnel to develop decision−making skills required for house−clearing operations that can be applied to different environments. The aim of this project was to provide program requirements to understand and train the recognition of perceptual cues used to diagnose events and coordinate actions during house−clearing missions. A cognitive task analysis was employed to identify the critical cues house−clearing teams use to assess their environment and establish shared situational awareness. A critical cue inventory was developed, based on which recommendations were provided on how to integrate critical cues into effective training simulation.

(U) L'accroissement de l'urbanisation a eu pour effet d'augmenter le nombre d'opérations militaires en terrain urbain (OMTU), dans lesquelles les unités se trouvent à œuvrer dans des agglomérations plutôt que dans des champs de bataille inhabités comme autrefois. Les OMTU présentent aux soldats et à leurs dirigeants un cadre particulièrement difficile. En plus de mettre au défi les habiletés tactiques élémentaires, ces environnements obligent les effectifs à prendre des décisions accélérées et plus poussées en fonction d'une multitude de données environnementales. Il est important que les effectifs acquièrent les compétences en prise de décision nécessaires aux opérations de nettoyage (ratissage) de maisons dans différents contextes. Le projet avait pour but d'énoncer les exigences du programme en vue de comprendre et d'enseigner les signaux perceptuels qui permettent de diagnostiquer les événements et de coordonner les mesures à prendre durant les missions de nettoyage de maisons. On a employé l'analyse cognitive des tâches afin de relever les signaux critiques qu'utilisent les équipes de nettoyage de maisons pour évaluer leur environnement et instituer une connaissance commune de la situation. On a aussi constitué un répertoire des signaux critiques, à partir duquel on a formulé des recommandations sur la façon d'intégrer les signaux critiques à des simulations d'instruction efficaces.

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(U) Cognitive task analysis, scenario−based training, house clearing teams